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JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION

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POST-WAR PLANNING FOR BRITISH OFFICIAL STATISTICS

By Richard O. Lang
War Department

FOREWORD

In the *Journal of the Royal Statistical Society*, Vol. CVI, Part II, for 1943, there appeared a report to the Council of the Society on the subject of British official statistics. As this report is the first of its kind[1] to have been written in many years it was believed that this "Memorandum on Official Statistics" would be of interest to readers of this Journal. Having worked in London for the greater part of eighteen months ending in February, 1944, working with British official statistics and statisticians, I was asked to select from the Memorandum important parts for summarization. It is my belief that the British experience in war-time and the hopes of the Society for the future may be useful to those persons in our country who are interested in looking forward to further development of our own Government statistical services.

INTRODUCTION

The publication of the "Memorandum on Official Statistics" by the Royal Statistical Society has given to the Society's members and to interested officials in the British Government a review of the existing organization of statistical services and recommendations for the post-war period. Official statistics have been the subject of investigation by committees of the Society for many years. As early as 1877 a committee was appointed to investigate the scope and organization of statistical work in the Government. One of its recommendations was that there be set up a small, central statistical office with limited supervisory author-

[1] The writer was in London in 1937–1938 as a Post-Doctoral Fellow of the Social Science Research Council and included in his work an examination of the work being done in official statistics in Great Britain. A brief summary of the findings of that investigation was prepared for the 24th Meeting of the International Institute of Statistics which met in Prague, Czechoslovakia, in 1938. The report was published by the Institute with an article on the United States by Stuart A. Rice, under the title, "The Organization of Statistical Services in the United States and Great Britain."

ity. No action, however, was taken on this recommendation. After World War I a petition to the Prime Minister requested an official ininquiry into Government statistics, but the committee appointed by the Cabinet in 1920 to review the petition recommended that although no case existed for an inquiry, there should be set up a consultative committee on statistical work of the Government Departments. This committee was established. It is of significance that the Royal Statistical Society should again set out to investigate the same problems but this time not waiting for the war to cease and the interest and importance of statistics to be forgotten.

The "Memorandum on Official Statistics" was the result of work done by a committee appointed by the Council of the Royal Statistical Society on October 13, 1942, with the following terms of reference:

> To consider and report upon the organization of statistics in Government Departments before, during and after the war, with special reference to—
> (a) the staffing of Departments;
> (b) the relations between Departments;
> (c) the advantages and disadvantages of alternative schemes of post-war organization.[2]

The committee consisted of Professor Major Greenwood (Chairman) Mr. R. F. George, Mr. M. G. Kendall, Mr. H. Leak, Professor E. S. Pearson, and Dr. E. C. Snow.

In the introduction to the report there is a brief discussion of definitions of "statistician" and "statistics," pointing out that "the science and methods of statistics in the modern sense range from the mere recording and tabulation of numerical data to subtle processes of inductive reasoning based on the mathematical theory of probability,"[3] and the word "statistician" being used to indicate anyone doing either the recording or the subtle processes of reasoning, or any of the work which lies between these two areas. The problem of establishing criteria for classifying a person as a statistician is mentioned, but not discussed; it is apparently left as a problem for attention of the Society in the future. The classification of statistical work is sufficiently interesting to be given in its entirety here:

> (a) "Descriptive" statistics, which cover the collection, summarization and interpretation of numerical material without reference to questions of sampling or the problems of representativeness associated with the theory of probability. The great bulk of departmental statistical work is "descriptive" in this sense. In its most primitive form it amounts to little more than recording and tabulating. The interpretation of the material, however, calls for that distinctive flair which is the characteristic of the true statistician. Such

[2] The *Journal of the Royal Statistical Society*, Vol. CVI, Part II, 1943, page 145.
[3] *Ibid.*, page 146.

> interpretation is work of a very high expert order. The tabulator and summarizer we shall refer to as a "statistical clerk." The interpreter may fairly claim to be called a "statistician." His theoretical equipment need not be very large—it is rare in this class of work even for such elementary functions as standard deviations or correlation coefficients to be required—but he must possess an expert knowledge of the limitations of his material, be able to draw sound logical conclusions from them and (what is of great importance in the Civil Service) to express those conclusions in a form which can be grasped by the layman.
>
> (b) "Mathematical" statistics, which cover the more specialized theory capable of application to testing the significance of sampling enquiries, to various forms of scientific experiment and to a whole range of problems in which the Government as producer or user is interested in the control of quality, whether of human beings or of products of industry. In many such problems it is being widely realized that the scientific approach is in fact the statistical approach. The statistician engaged in this class of work must have a considerable knowledge of mathematics and a scientific mind. He also should possess the flair for figures of his "descriptive" colleague, and if he is to pull his weight in any organization his analytical skill in mathematics must be tempered with common sense and sound judgment. There is not (or ought not to be) any antagonism between the descriptive and the mathematical statistician; in fact some people are both. The broad distinction is similar to that between the general practitioner and the specialist in medicine, and it is from this angle that the distinction becomes important for our present purposes.[4]

It is significant that the committee consisted of a balance between the "descriptive" and the "mathematical" statisticians, and the Memorandum clearly shows this balance throughout its pages.

THE PRE-WAR POSITION

The pre-war position on collecting statistics might be stated simply that each Department collected its own statistics. In many instances there was no statistical branch even in major Departments, and where such statistical offices did exist, the practice was for each office to deal with the data required for its own work. There was emphasis upon the administrative aspects of statistics, and it is readily understandable why the organization of statistical services, particularly the collection of statistics, was decentralized. The Departments had no general powers to collect statistics as they required them. The limitations on their work were far more severe than limitations imposed upon United States Government Departments in similar work. Certain regular activities of a few Departments were established by laws, the decennial population census, the annual agricultural census, the registration of births and deaths, and the like, but for the most part even these in-

[4] *Ibid.*, page 147.

quiries were carefully limited in the scope and number of questions which could be asked. Although there were few formal statistical inquiries, there had accumulated an enormous mass of statistics as by-products of administrative functions. The principal features of this mass of information seemed to be:

> (a) That most of it was collected for some special administrative purpose or as a consequence of some administrative duty, and not for its own sake. As a result it was frequently not in the form most suitable for statistical study.
>
> (b) That it was acquired by branches concerned with administrative work and was therefore sometimes not properly recorded and summarized.
>
> (c) That in consequence of the system of collection by individual branches there was in many cases very imperfect co-ordination even between branches of the same Department in the collection of the material.[8]

These defects are familiar to many readers of this JOURNAL and could well describe some of the statistical work in our own Government agencies. Much has been done in the United States, however, to alleviate such strains by the co-ordinating work done first by the Central Statistical Board and now by the Division of Statistical Standards in the Bureau of the Budget.

Arising out of the defects in the system of collecting statistics were many inadequacies in the presentation and analysis of the data. The information was frequently summarized in a form which even the Department responsible for the collection had difficulties in fully utilizing the material. The greatest need was for better summarization and wider utilization of statistics already available. In those Departments which had separate statistical branches this criticism does not necessarily apply. But on the whole there were too many instances of information published in regular reports which were not fully utilized.

Along with these defects were the unsatisfactory results arising from untrained staffs trying to carry on the tasks of collecting, recording, and summarizing the information. Most of the work had been done by ordinary clerical officers who had no training either in descriptive or mathematical statistics. No technical statisticians were brought in to advise the Departments in their statistical work. (The exceptions to this, of course, are the four Departments who had separate statistical branches.)

The consultative committee on official government statistics mentioned in the first part of this paper was appointed to co-ordinate departmental statistics. The main work of the meager staff of the committee was the publication of an annual "Guide to Current Official

[8] *Ibid.*, page 149.

Statistics of the United Kingdom," and it exercised little influence on departmental statistical practices. Only in a few instances had any attempt been made either by this committee or through any other means to co-ordinate official statistics. Personal contacts among members of Departments may have accomplished what little co-ordination there had been, and the meetings of the Royal Statistical Society probably formed the only other place where men talked over common problems and plans. The pre-war position, as summarized in the Memorandum, is as follows:

> A general survey of departmental statistics before the war gives the impression of very wide differences in practice and performance. In only a few of the major Departments was there any statistical organization which can be regarded as adequate. In the others the limited needs of the Departments seem to have been met by improvisation. There was little liaison between Departments. The system under which each Department, and in many cases, each branch of each Department, was responsible for the collection and handling of its own statistical material, though containing useful features, tended to result in inadequate use being made of available material and in dissipation of effort. The staffing of Departments was unsatisfactory in regard to the training of personnel, and in certain respects to their status. Nowhere was a knowledge of statistical theory regarded as a necessary qualification for employment in statistical work and the technical post of "statistician" was practically unrecognized.[6]

WAR-TIME DEVELOPMENTS

In takes no expert imagination to predict what happened when war broke out in 1939 and the administrative Departments had thrown on them burdens for which they were never organized to carry. In addition the numerous new Ministeries, particularly Food, Supply, Aircraft Production and Economic Warfare, made immediate and large demands for statisticians of both the descriptive and mathematical types. Soon qualified personnel was in acutely short supply, and has remained so during the entire war period. The shortage has been so great that many persons now employed as "statisticians" in Departments have never had the training or experience which normally one would expect of personnel which claim that title. This is not much different, however, than some of the conditions in this country when our "defense effort" in 1940 called for "experts" in munitions production control organizations; "statisticians" found jobs which earlier would have required more exacting qualifications by the Civil Service examinations. The British found not only a shortage in technical people but the shortage in statistical clerks was severe enough to call for a scheme for training in the Civil Service. Concentrated courses of eight week's duration have

[6] *Ibid.*, page 153.

been given by the London School of Economics at Cambridge in order to get some qualified personnel into statistical offices in the various Departments. Not only the "descriptive" statistician was needed, but the complexities of modern warfare required the skills of the mathematical type as well.

From the long term point of view, however, the war has given statistics the greatest lift it has had in many years. Benefits derived from the extensive use of numerical data in all types of problems are many indeed. One of those benefits has been a changed attitude towards statistics and statisticians. Individuals and organizations are more willing than ever before to give information which is collected for administrative purposes and summarized in statistical form; the great increase in the amount and scope of questionnaires during war time has met with very little resistance. The public believes that a war must be run on facts, statistical facts. Besides the changed public attitude toward statistics, there has been a real change of heart among the Government Departments which in peace time regarded the statistician as follows: "at best he was considered a harmless drudge, at the worst a nuisance who was apt to produce figures at the wrong moment to weaken a promising line of argument."[7] Government Departments now seek for statistics and the statisticians qualified to analyse them.

The most significant war-time development, and of particular interest to us Americans, was the establishment of a Central Statistical Office within the Offices of the War Cabinet, in 1941. Its main functions include:

> (a) to ensure that the requisite figures should be collected by Government Departments in a systematic manner;
>
> (b) to arrange, when necessary, for inter-departmental discussions on all statistical questions;
>
> (c) to maintain day-to-day liaison between the statistical branches of the Departments and with the Central Executive, so that agreed figures could be accepted and used without question in inter-departmental discussions;
>
> (d) to compile statistical information for the War Cabinet and its Committees;
>
> (e) to act as a central organization for the circulation of statistical information between Departments.[8]

The establishment of the Central Statistical Office came after the country was used to running on a war-time basis. Accurate and current information on many subjects was required. The weaknesses of the pre-war organization for statistical work were brought into bold relief, particularly the inter-departmental liaison. "The close relationship be-

[7] *Ibid.*, page 156.
[8] *Ibid.*, pages 154–155.

tween such diverse matters as shipping and agriculture, aircraft production and rubber stocks, food rationing and recruiting programmes—to mention only a few—meant that there was a keen necessity for some body which could bring all the statistical information together and reduce it to a coherent and comprehensible form for the Government's use."[9] The Central Statistical Office has acted as an impartial, objective agency to present complete, related statistical data, and fortunately has had no axes to grind, no departmental obligations to fulfil, in presenting the information one way or another. It has improved the collection and presentation of statistics by the Departments themselves by requiring a higher quality of product for use in the Consolidated Statistical Reports prepared by the Central Statistical Office. The Office has been a co-ordinating agency in the field of official statistics, both descriptive as well as mathematical.

REQUIREMENTS FOR THE POST-WAR PERIOD

The two principal post-war problems investigated and reported on by the Committee who prepared the Memorandum were (1) the staffing of statistical units and (2) the co-ordinating machinery. The consideration of several schemes of post-war organization was based on the assumption that "the Government's demand for comprehensive statistical information during war-time will continue into the post-war period and beyond."[10] It was believed that State intervention in many post-war developments such as social insurance, national or international regulation of exchange, currency and trade would make it impossible for the Government to go back to the pre-war organization. Government Departments have tasted the fruit of statistics and probably will be unwilling to forego it in their post-war diet. The Committee assumed that statistics and statisticians were there to stay.

The Committee's comments on and recommendations for the post-war period are comprehensive. The Government Departments have not had full-time statistical offices as they are known in United States Government service. The recommendations, therefore, are far-reaching, but at the same time do not appear too radical in the light of the present administrative machinery in the major Departments. Compromises with existing Civil Service regulations and practice had to be made, the scale of salaries and the status of the statistician in the Departments had to be considered. These, and related issues, are woven into the final recommendations appearing in the Memorandum. Recommending that every major Department have a statistical branch with an officer of

[9] *Ibid.*, page 155.
[10] *Ibid.*, page 157.

the administrative grade, the Committee nevertheless recognizes the importance of not disrupting existing machinery for certain work. Decentralization on the collecting, recording and summarizing levels are taken for granted.

One of the more serious problems is that of getting qualified staff for the proposed branches. It has already been pointed out that staffing the war-time agencies admitted to the ranks of statisticians many who would not qualify for such work under pre-war requirements. In its recommendations the Committee suggested the following:

(a) There should be definite statistical appointments carrying salaries comparable with senior officers in the administrative grades.

(b) A special recruitment policy should be established which would bring technically qualified statisticians into the Civil Service.

(c) Junior administrative officers should be required to spend some time in the statistical branches in order that administrators of statistical branches would have some familiarity with statistical methods.

(d) Positions of technical statisticians should be established in some Departments to give sound statistical advice as well as for the work of interpretation and analysis of Departmental statistics.

(e) Departments should not be limited to selection of supervisory and junior staff from within the Departments, if it is found that there are not suitable personnel available.

(f) In-service training courses in statistics, begun during the war period, should be encouraged and extended.

The Committee felt very strongly that the status of the statistician should be on the highest plane, and to ensure that this status might be attained it recommended that the statistician's role in departmental work go beyond statistics into the field of administration; top administrative grades in the Civil Service carry high prestige in Government circles.

In the view of the Committee, of highest importance in the requirements for the post-war period is the co-ordination of statistical work of the Government Departments. By co-ordination the Committee included the output of Departments, the standardization of practices, and the status of the personnel. It was clear to the Committee that the only practicable organization to be charged with functions of co-ordination would be a Central Statistical Office. Rather than summarize the Memorandum of these points, full quotation of the pertinent paragraphs is given:

> The existence of a Central Statistical Office at the present time and the necessity for that Office to continue in existence for some time after the end of the war may render it more easily incorporated into the future Govern-

ment organization than if it had to be set up afresh, as was recommended by the Society after the last war. It is of prime importance that the head of the Office should be selected for his personal as well as his statistical qualifications. He would occupy a post of the greatest importance and responsibility, and in view of the proposed functions of the Office in regard to co-ordination he should not only command the respect of statisticians inside and outside the Service, but be able to maintain close and cordial relations with many Departments with whom he would come in contact. Much would depend on his initiative, tact and vigour, and we think that these qualities, rather than statistical eminence, should determine his selection.

One of the important functions of the Central Statistical Office would be to standardize the methods of different Departments (e.g., in regard to definitions, classifications and time periods) and to co-ordinate their work in order to ensure comparability, the avoidance of duplication and the collection of adequate material where required for the Central Government. The problem is to ensure that the co-ordination will be really effective and that Departments shall work harmoniously as part of a national statistical service without encroaching more than is necessary on individual freedom of action. It would assist in this direction if the Central Statistical Office were advised by a small Committee of not more than, say, six or eight members selected from among the heads of statistical branches in the major Departments for their outstanding statistical qualifications. The same Departments would not invariably be represented, and vacancies should be filled on nomination by the remaining members. The Chairman of the Committee should be the head of the Central Statistical Office, and that Office should be under an obligation to consult the Committee on all important questions. Probably regular meetings of the Committee would be advantageous in keeping the members in touch with current problems and in touch also with one another. To make the Committee as effective as possible we recommend that it should be empowered to initiate subjects for discussion, and to issue reports on statistical matters which do not fall within the province of any single Department. We think that in this way the Committee would carry great weight and its decisions would generally be acceptable to all parties concerned. In the event, however, of objection being raised by any Department, there should, we think, be suitable machinery for referring the matter at issue to an appropriate Committee of the Cabinet.

We contemplate that there will be need for an Economic Section of the Cabinet after the war and that the Central Statistical Office will form a parallel unit. In this capacity it would have the primary duty of compiling statistical information for the Cabinet and its Committees on subjects where the interests of more than one Department are concerned.

Though there may be divergence of views as to the detailed post-war organization of the Central Statistical Office, the following principles should, in our view, be observed in reorganizing the Office after the war:

(a) It should be no part of the duty of that Office to relieve Departments of their responsibility for collecting and compiling statistical data. There is no suggestion that such work should be brought together under one enormous unit.

(b) The Office should be divorced as far as possible from routine analysis and from administration.

(c) It should be charged with the duty of preparing statistics required by the Government, such as the Budget White Paper, or by such bodies as Royal Commissions and special Committees appointed by the Government.

(d) It should ensure that as much statistical material as possible is made available to the public and that all Government statistics are issued with the minimum of delay.

(e) It should endeavour to fill gaps in statistical information by advising Departments on the desirability of certain lines of enquiry.

(f) It should undertake research work or loan staff to assist other Departments in undertaking such work.

(g) It should act generally as a co-ordinating body.

(h) It should be responsible for the issue of the *Statistical Abstract for the United Kingdom* and the *Guide to Current Official Statistics.*

(i) It should also be responsible for the publication of a monthly bulletin of statistics on the lines of the *Survey of Current Business* by the United States Department of Commerce.[11]

The Committee regarded the Central Statistical Office as a kind of reservoir for trained statisticians who could be loaned or transferred to statistical branches in the Departments. The Office could also act as a place where Departments might station one of their staff for further training, and the experience on this new level would be invaluable not only to the person stationed but also to the Department. Such an organization would also enhance the uniformity of practice between departmental statisticians as well as provide an unequalled opportunity for contact and future liaison.

The Committee was fully cognizant of the time required to put into effect the proposals presented in the Memorandum. It recognized that governmental organization and procedures cannot be changed in a few weeks or months. The co-ordination and improvement of statistical practices, the raising of statistical standards, the fuller utilization of statistics in administrative work and the enhancement of statisticians' prestige in the Government—all these were expected to take a period of years to accomplish.

[11] *Ibid.*, pages 161–163.

INTERNATIONAL PROGRAMMING OF THE DISTRIBUTION OF RESOURCES: A SYMPOSIUM*

I

THE PROBLEM OF COMBINED PLANNING

By William L. Batt
War Production Board

In considering the possibilities of combined planning in the international field, we have a great deal to learn by looking back at our own national planning in these years since the National Defense Advisory Council began to work over in the Munitions Building.

The task of the War Production Board and its predecessors has been to divert resources, which in peace time move under the direction of private markets, to the production of weapons of war and essential civilian goods, and to maximize the use of all our resources and achieve a maximum production of the things that we want in war time.

This task involved the mobilization of all our resources, of which the accumulated skill, experience, and willingness of our people comprised our most important asset. What we had at the beginning of the war in the way of inventories and facilities was far less important than what we had in the way of a skilled labor force, managerial business and public experience, and the skills of the highly trained professions.

The success of the war production effort rested largely upon maximum utilization of the skills of the workers; the experience of the managerial groups, the knowledge of technicians, engineers, and natural scientists; and last, but not least, the technicians and scientists in the field of economics and other social sciences. Of these, skill and experience in the field of measurement of resources, production, distribution, and consumption of commodities and services, on a nation-wide scale (and often on a *combined* basis), were fundamental in the management of the war production effort.

As we all know, the job of mobilizing for war has been much greater in the present conflict than it was in the first World War. Further, we faced the task of mobilizing for war against a background of national danger and an urgent need for quick action even greater than in 1917.

* These papers devolve from a dinner meeting devoted to a discussion of the Combined Boards held in Washington, May 6, 1944, as a part of the Regional Meetings of the American Statistical Association. The session had six United States, British, and Canadian participants. The present symposium contains the remarks of Mr. William L. Batt, International Vice Chairman (International Supply) of the War Production Board, who presided at the session and directed the discussion, as well as the comments of one British and one American participant.

In this enormous task, a knowledge of our resources, potentialities, and requirements, such as could be provided by statistical measurement and controls, was fundamental.

It was indeed fortunate that when the defense period began, and especially from the time of our active participation in the war, we had available statistical data and techniques, and a reserve of experienced economic statisticians and analysts to a far greater extent than in World War I.

Since the last war there has occurred a great enrichment of our economic statistics and of the experience in applying statistical tools to problems of the national economy. The work of the Department of Commerce and of the Bureau of the Census secured great impetus from the lack of data shown during World War I. Research institutions, such as the National Bureau of Economic Research and the Brookings Institution, were World War I babies, founded by people like Brookings, Edwin F. Gay, and Wesley C. Mitchell as a result of their experience in the old War Industries Board. With the resulting increase in data and analysis, academic training began to emphasize quantitative analysis of problems of the national economy; and thus raised the level of statistical experience and analytical capacity of the generation graduated after World War I.

Statistical analysis enters into the work of the War Production Board in many ways. Only a few of the more important will be mentioned here.

First, we had to see what the economy could produce in order to get a basis for determining the over-all size of military production programs that could be carried through. In this work we have used data, in large part familiar on the total national product, the size of the labor force and the extent to which it could be expanded, the supply of critical materials, levels of past and possible civilian consumption, and so on.

Here there was a long evolution, from the early days when emphasis was on showing how large the munitions programs could be and pressing for an early formulation of such programs in anticipation of the conflict, to later phases when the cumulation of programs, each elaborated by the several military agencies, threatened to exceed the productive capacity even of our great economy and result in dislocation; to still later phases when military and civilian programs were in general balance with the capacity of the country, leaving room only for special problems; and finally to recent months when planning for a possible decline in the war production levels began to be practicable.

Secondly, we had to analyze closely the supply and requirements for certain critical types of resources—materials, various types of pro-

ducers' goods, facilities, transportation (particularly shipping), and more recently labor. In this case, the detailed programs of the several claimant agencies had to be analyzed, translated into the claims which they represented—quarter by quarter—upon limiting resources, and compared with the supply of such resources that could be assured. These were basic to decisions either to expand the resources, or to moderate the claims, or to do both. In a sense, this laborious task of statistical matching of demand and supply—not in market but in war production planning terms—was a detailing, on a shorter time scale, of the broader type of planning and programming.

Third, in addition to analyzing the forward programs and claims, as well as the future supply of resources, the statisticians had to sharpen their tools for recording what was being actually accomplished. In this task, there were encountered the usual problems of accurate and prompt reporting at the least cost; of bringing together the reports in a unified form, comprehensible to the executives who were responsible for decisions; of analyzing what happened with emphasis on the choke-points that called for immediate attention—in short all the usual problems of statistical control magnified enormously by the scale of operations and fluidity of events.

In these various ways, and in many others, statistical work in the War Production Board has been fundamental in: (a) providing the broad framework within which policy could be laid down; (b) checking conflicting claims, and reducing the area within which decisions had been made by hunch; (c) assisting us in keeping abreast of events and aware of what portended in the future.

Naturally, there were shortcomings. Because of lack of data, the conclusions could not be detailed, and in some cases too much room was left to decisions by hunch. Because of the fluidity of events, the broad plans in some cases showed unwarranted biases. Because of the difficulty of reducing the thousand-and-one things to common denominators, there was sometimes disagreement among the statisticians and economists themselves, to the confusion of the policy executives. But one could claim that the shortcomings were within the margins that have to be tolerated in a generally imperfect war-disturbed world.

The applications of statistical techniques and data, such as were made in the War Production Board, should provide a basis for rapid progress of the discipline in the post-war future and of its application to post-war problems of the national economy.

This would parallel the development after World War I. And perhaps one could hope that the comparatively successful use of the techniques during the war would be followed by a similarly successful use after the

war, certainly on any economic or social problem on which we shall secure the same unanimity of social will as we had during this war effort. Even on problems on which disagreement may justifiably exist, the application of statistical techniques should at least narrow the area of legitimate controversy.

There has been general recognition of the great impetus which war gives to the advancement of technology in the natural science and engineering fields. Most people are at least generally cognizant of the potential gain to human welfare that may come from the developments of this war of penicillin, of blood plasma uses and techniques, of the tremendous advance in insect-control devices which promise to revolutionize our methods in the field of epidemiology. We can look forward to widespread civilian use of such devices as radar, and numerous aircraft developments, and the many new applications of mass-production techniques to precision instruments which formerly could be produced only in small volume and by painful effort.

But there has been less general recognition of the similar impetus which the catalyzing effect of unified national purpose has given to the development of data and methods essential to the understanding of national and international economies. Our abilities to deal with problems in this field may be fully as decisive to human welfare as anything in the field of natural science or engineering. There is good ground for optimism that the work done by our economists and statisticians in this war, built upon a foundation forged in World War I, will serve to further the great task of fashioning a post-war economy that will minimize the scourges of world poverty and disastrous recurrent depressions.

Turning now to the work of the Combined Boards—but leaving to the two following papers the explanation of how the Combined Boards operate and what their detailed accomplishments have been—something very briefly should be said about the general principle on which the Boards have operated, at least the Combined Production and Resources Board and the Combined Raw Materials Board and something also on the possibilities of combined planning in the future.

Two things about the work of the Production and Resources and the Raw Materials Boards should be emphasized. Both have to do with the word "combined" that appears in the title of each. First of all, the Boards and their charters establish the principle of pooling of resources of the United States and the United Kingdom (and in the case of the Combined Production and Resources Board, also of Canada). In the raw materials field, for example, we have really worked on the principle of "what is thine is mine, and what is mine is thine." In the interests of winning the war, every pound of the materials originating in the

British Empire or the United States has been available for use in either country where it can do the most good. Secondly, the Combined Boards have provided a common table around which ideas, opinions, and problems, as well as resources, could be pooled. The Boards have not operated as autonomous agencies and independent of the operating departments of the Member Governments. In effect, the Boards *are* these national agencies. On the American side, the Boards provide a place where the War Production Board, the Foreign Economic Administration, the Department of State, the Department of Commerce, and other American agencies can bring their problems in the international field and talk them out with their British opposite members until agreement is reached. This point cannot be over-emphasized. Without an intimate two-way flow of opinions and recommendations between the Boards and the operating agencies, successful planning on a combined basis would have been impossible. But with this cooperation, the Boards' actions have been taken with the benefit of the experience and advice of all the operating agencies concerned, and the Boards' recommendations have been implemented without question, because in every case these recommendations were in effect also the recommendations of the operating agencies who were responsible ultimately for putting them into effect.

The Combined Boards are war-time agencies. They are not equipped in their present form to carry over into the post-war period. Their job has been to solve the problems of war-time shortages, and their job will be largely done once these shortages disappear. In my mind, however, it would be nothing short of tragic if the accumulated experience of the Combined Boards in the field of international economic cooperation were to be lost. I am a firm believer in the advantages of private enterprise and free markets. I am also a firm believer in the absolute necessity of international cooperation in the economic as well as in the political field. Peace and progress will depend upon that cooperation being secured. I believe the Combined Boards show how successful such cooperation can be when there is complete agreement as to objectives and as to the general means of achieving these objectives. It will be up to us and the peoples of other nations to see that the agreement as to ends and means is secured for the post-war world.

II

STATISTICS AND COMBINED PLANNING

By R. G. D. Allen
Combined Production and Resources Board

Improvement of economic statistics, nationally and internationally, during the war has been pronounced and the Combined Boards have encouraged some of the improvement. Though this applies specifically to statistics in the United States and the United Kingdom, it applies in varying degrees to other countries—to Canada which is a member of several of the Combined Boards and to such United Nations as Australia, India and Brazil which are not directly represented on the Boards.

Particularly, statistical material in the broad economic field has been very greatly improved during this war in the United States and in British countries. This would have happened, to a considerable extent, if the United States and British had fought the war independently of each other. It happened in the war of 1914–18 when much of the planning was, in fact, done independently. The outstanding characteristic of this war, however, is the extent of Anglo-American cooperation. This has accelerated the advance in the quantity and quality of national statistics and has directed it on parallel and comparable lines in the various countries.

In this war, unlike the last, Anglo-American cooperation has been close from the beginning. Some strong links were already forged at the time of Pearl Harbor and many others have been added since. Washington and New York accommodate numerous British Missions, the personnel of which far outnumber the regular diplomatic and consular representation. The United States counter-invasion of London, though slower in starting, is now on a comparable scale. These groups are more than Missions to a foreign country. They are pulled together with the domestic government agencies through the system of combined organizations both on the military side under the Combined Chiefs of Staff and on the civilian side under such Boards as the C.F.B., C.R.M.B., and C.P.R.B.

Amongst the British in the United States and amongst the Americans in London are many professional economists and statisticians. Other United States and British experts are working side by side in Cairo, New Delhi and other distant places. The war has brought economists and statisticians together more often and more continuously than was ever possible in the more leisurely days of peace.

As a result, United States statistics have become more familiar to British statisticians, and British statistics to United States statisticians. Before the war, all that some British statisticians knew about United States statistics was that they were voluminous, incomprehensible and perhaps unreliable. Many of them can now pick the right series out of the small type in the *Survey of Current Business* at the first attempt—and can argue with at least some show of knowledge about the relative merits, for example, of the Bureau of the Census and the Bureau of Labor Statistics data on non-agricultural employment. Similarly, the horizons of the United States statistician have been extended. I have a feeling that some of them were wont to think that British economic statistics were scarcely worth a second thought. They are now far more familiar with the wartime confidential *Accounts Relating to Trade and Navigation of the United Kingdom* than they ever were with the similar statements published before the war.

This is not a case of familiarity breeds contempt. On the contrary, the amount of patient care and hard work that goes into statistical compilations can be appreciated only after close study and frequent use of the final product. Familiarity with the statistics of another country, moreover, may well turn the statistician into a reformer. United States and British statistics alike can be improved by a study of what is done in the other country.

The inescapable needs of the war economy in each country separately have led to extensive improvements in the national statistics. In the United States, I need only mention such published series as those on consumer expenditures, civilian labor force, hours and earnings in industry and the value of new construction; all these and many others have been developed or extensively revised since 1940. In addition, a mass of confidential material has been collected by United States war agencies covering almost every aspect of production, manpower, transportation and other economic fields. Some of this material is now being released, notably in *Facts about Industry* issued jointly by the Bureau of the Census and W.P.B. Much of the wartime collections of statistical data will inevitably be dropped but the utility of some of the new series is so evident that they have a good chance of survival after the war. In the United Kingdom, where government statistics have hitherto been the jealously guarded preserve of separate and individual government departments, an early wartime development was the creation of a Central Statistical Office within the Offices of the War Cabinet. Little of the work of the C.S.O. has been publicly issued except for the invaluable annual White Paper on the sources of war finance and the national income and expenditure. It can be said, however, that the regu-

lar statements prepared confidentially by the C.S.O. contain many statistical series which were not available before the war. It is clear from the trend in British government policy (e.g. the recent White Paper on *Employment Policy*) that the work of the C.S.O. in collecting and compiling statistical series in conjunction with regular government departments will continue when the war is over.

Domestic necessity has been the most powerful, but certainly not the only, influence in bringing forth data previously unobtainable. In numerous instances a request from an American agency in Washington or from an American Mission in London has disclosed that the needed information was not readily available in the United Kingdom. As a result the data have been collected, found useful and kept up-to-date; a new series has been added to British official statistics. Requests from Combined Boards in connection with the many subjects under consideration have likewise improved and extended British statistics. The same is true on the United States side, though here the result may be an improvement in existing data more often than a development of new series.

At this stage, a few words about the functions and organization of Combined Boards are relevant. The job of the civilian Boards is to make recommendations to the several national agencies concerning the production and allocation of foods, raw materials and finished products to the best advantage of the combined war effort. The Boards neither execute nor dictate. They serve to bring before the national agencies the world picture as opposed to the narrower view inevitably taken by government departments individually and separately. To be able to function at all, therefore, the Boards need to set up in business as fact-finding agencies on a global scale. Their organization has developed in several ways which cut across each other but which proceed primarily through committees handling particular commodities or concerned with particular areas. Whatever the grouping may be, the first need is for the statistical facts—about the world demand and supply position on fish or coal, on copper or textiles—about the needs of particular areas for relief and rehabilitation.

The concept of a world "balance sheet" for a particular commodity is simple enough—setting consumption and requirements against production and stocks. The technique of preparing such a balance sheet has been well developed by the Combined Boards and it is still being improved. Often the preparation of a balance sheet is enough in itself to disclose problems before they become critical and in time for the national agencies to take appropriate action. The success of this line of approach to combined problems depends on free and rapid exchange

of information between the agencies of the governments concerned. This has been achieved to a very remarkable extent during the two years that the Combined Boards have been in operation.

In many ways the work has been similar to some of the activities of the Economic Section of the League of Nations and of the International Labor Organization between the wars. There are, however, very important differences. In the first place, the Boards have not built up expert staffs to the extent undertaken by the League. Instead they have relied heavily upon the experts within the agencies of the several nations concerned. This has had the advantage of keeping the Boards extremely close to those ultimately responsible for national statistics while bringing together the experts from individual countries. Secondly, though the problems raised for combined consideration often do not have the breadth and scope of those taken up by the League, they are usually much more specific and certainly of more immediate urgency. In short, something has to be done about a problem and done quickly. The invasion of Europe cannot wait for months while, for example, exhaustive and careful examination is given to the question of the supply for coal for military operations and for the relief of liberated territories. A world coal "budget" must be drawn up quickly and kept constantly up-to-date. Such statistical problems as the comparability of various inventory figures must be resolved as far as possible in the time.

A good deal has been done on these lines and a large measure of agreement has been reached on such things as the definitions used in compiling data on steel supplies and stocks or the categories and units for the display of textile production figures. Under the auspices of the Combined Boards, expert missions have been exchanged between the United States and the United Kingdom to solve technical and statistical problems such as these. It is important that this work should not be lost in the postwar years.

Wider and more academic problems of an economic or statistical nature are being tackled to an increasing extent on an international basis, particularly as the questions of transition from war to peace are given more attention. These problems may be handled best at a series of international conferences such as those at Hot Springs, Va., in 1943 and more recently at Bretton Woods, N. H. The Combined Boards are directly concerned with these problems. As an example of what has been done there need only be mentioned the study of food consumption levels in the United States, the United Kingdom and Canada undertaken by the Combined Food Board. A survey of the results of this study has been issued publicly, some of the material being summarized in the President's *Fifteenth Report to Congress on Lend-Lease Operations.*

Other work of this nature in the fields of civilian consumption, manpower and national income has been done and is still proceeding. Material of this kind will be invaluable for economists to work on after the end of the war.

But the main legacy of the present combined planning for the war will not be any compilation of statistical material, or even a set of definitions and categories for comparable international statistics. It will be the wider experience and the international habits of thought acquired by so many economists, statisticians and other experts now in the service of their governments.

III

THE COMBINED RAW MATERIALS BOARD*

By R. A. Gordon
Combined Raw Materials Board

Organization of the Combined Raw Materials Board was announced by President Roosevelt and Prime Minister Churchill in January 1942. At the same time, formation of two sister combined agencies, the Munitions Assignments Board and the Combined Shipping Adjustment Board, was also announced.[1] The charter of the Combined Raw Materials Board provided that it should:

(i) Plan the best and speediest development, expansion and use of the raw materials resources under the jurisdiction or control of the two Governments, and make the recommendations necessary to execute such plans. Such recommendations shall be carried out by all departments of the respective Governments.

(ii) In collaboration with others of the United Nations, work toward the best utilization of their raw materials resources, and, in collaboration with the interested nation or nations, formulate plans and recommendations for the development, expansion, purchase or other effective use of their raw materials.

More than two years have passed since the Board was formed—enough time to indicate clearly the highly tangible and gratifying results that have grown out of the discussions of the President and the Prime Minister.[2] To date, the Board has issued nearly 300 decisions and about the same number of staff reports. More than 40 commodities have been brought under continuous review and have been made the subject of recommendations aimed at bringing supply and requirements into balance and insuring the orderly movement of adequate quantities from producing areas to the appropriate points of consumption.

Basically, the Board has performed the following functions. It has coordinated the activities of the United States and the United Kingdom in developing sources of supply where expansion was possible and needed to meet war-time requirements; it has exercised a similar co-

* The views expressed in this paper are entirely those of the author and not necessarily those of either the War Production Board or the Combined Raw Materials Board.

[1] Other combined agencies include the Combined Chiefs of Staff, announced in February 1942; and the Combined Production and Resources Board and Combined Food Board, both established in June 1942.

[2] The work of the Board has been described in detail in its First and Second Annual Reports, both of which have been publicly released. The first was issued in February 1943, and the second in May 1944.

ordinating role in planning the greatest possible conservation of use in consuming countries; it has recommended allocations to the various countries so as to achieve the most effective possible use of what was available; and, finally, it has provided a common table around which the interested agencies of the United States and the United Kingdom can work out answers to their day-to-day raw materials problems insofar as both countries are affected. A new and increasingly important function of the Combined Boards is to recommend allocations of supplies for relief and rehabilitation in liberated areas. This new activity looms larger in the work of the Combined Production and Resources Board and the Combined Food Board than in that of the Combined Raw Materials Board, since industrial raw materials will play a much less important role than food and finished goods in relief and rehabilitation programs.

In my opinion, the Board has been an efficient and gratifyingly successful organization. It has eliminated reckless and wasteful competitive buying in foreign markets between the major consuming countries in order to secure the maximum orderly flow of needed materials; it has helped to move promptly available supplies to points where they have been most needed; it has contributed to expanding supplies and to bringing about more economical use of materials in short supply. It has planned—in the very best sense of that over-worked word.

It also seems to enjoy the support and cooperation of all the interested operating agencies on both sides of the Atlantic. This cooperation is due in large part to the very wise policy initiated at the beginning that no decision of the Board would be made except after full consultation with all affected agencies. As part of this policy, all reports and decisions are cleared first with the government departments concerned, and on the Board's Operating Committee sit representatives of the State Department, War Production Board, Foreign Economic Administration, and Department of Commerce for the United States, and the comparable agencies for the United Kingdom.

At the end of two years of operation, the Board has been able to report that the raw materials battle has been largely won. While a few commodities continue to give grave concern, supply has been brought into balance for most of the important materials which bulk large in the war effort. (This is not to say, however, that in these cases all controls can be completely removed.) The wealth of resources open to the United Nations and their control of the shipping lanes are the primary factors responsible for this result. But the bottlenecks were broken sooner than they otherwise would have been because both nations agreed from the beginning on the need for central planning and co-

ordinated activities at all stages, from production through to final use.

In making its plans and recommendations, the Board has had the full benefit of all the statistical information that could be brought to bear on the subject under consideration. A simple statistical tool—a tabular presentation of stocks, supplies, and anticipated consumption (in Washington parlance inaccurately termed a "balance sheet") —has been the foundation of every commodity study prepared by the Board's staff. Not a few problems have arisen in achieving comparability between the production, stock, and consumption figures of the United Kingdom and the United States. Definitions, coverage, frequency of reporting, nature of the forms used by the supply agencies of each country in securing data from individual firms, and a number of other variables have added to the problem of securing reasonably comparable data.

The Board's staff has not sought for perfection. An admittedly substantial range of error exists in many of the figures and estimates that the Board has used, but the data have been good enough to provide a solid basis for the estimates and plans which have entered into the Board's work.

The wealth of information on particular commodities available to the Board will not entirely survive the war. Information reported to the national agencies is a direct function of the strictness of the controls imposed and of the degree of scarcity prevailing in the commodity. Already, as some materials have entered into a more comfortable position, controls have been relaxed and statistical information required of industry is being reported somewhat less frequently and in less detail than formerly. But the progress made in achieving international comparability has not been lost and should in good part continue into the post-war period.

For an economist, it has been a unique experience to deal with economic and business data and at the same time almost never see a dollar or pound sterling sign. The Board's data are almost exclusively in terms of physical volumes. It deals with requirements expressed in terms of pounds, tons, or yards, and with supplies expressed in the same units. Price is largely excluded from the picture. Evaluation of essentiality takes place, as it must, outside the traditional price mechanism. Data as to cost and price enter into the work of the various operating agencies, but the Board concerns itself with demand and supply expressed almost exclusively in "real terms." This is the essence of the rationing process, and the Combined Raw Materials Board, like the national supply agencies such as the War Production Board, has been charged with the responsibility for rationing industrial raw materials. Similar considerations apply in planning expansion of production. The

relevant costs are not those expressed in money terms but the "real opportunity costs," that is, what must be sacrificed to divert labor, materials, and equipment to this particular use and away from another line of production also important to the war effort.

THE FUTURE OF INTERNATIONAL ECONOMIC COOPERATION

The success of the Combined Raw Materials Board is matched in good part by that of the other combined agencies. This success naturally raises the question: Why cannot such international economic cooperation hold equally for the years of peace to come? Unfortunately, the experience of the Combined Boards provides more evidence of why it would be difficult to secure effective economic cooperation in the post-war years than a basis for expecting that international collaboration can be easily achieved. This is not to say that we cannot have international cooperation in the economic field—we can and we must. But we must not blind ourselves to the difficulties.

The success of the Combined Boards has been made possible by several favorable factors, none of which will exist in the same degree in the post-war world. First, and most important, there has been complete agreement as to objectives—the agreed aim, which has never been subject even to discussion, has been defeat of the common enemy. In the Combined Raw Materials Board, this has been translated into the criterion of producing and distributing raw materials so as to achieve the maximum flow of end-products needed for the war effort. This objective has been taken, quite properly, to be paramount and to override any and all differences of opinion that might arise. Thus the Combined Boards have been able to base their decisions on "supply" grounds with a minimum of reference to political, commercial, or financial questions that might be involved. When it has seemed necessary, public purchase has been substituted for private trade; sources of supply have been diverted from one country to another; materials have been transferred from one nation's stockpile to another's depleted inventories; equipment has been diverted from one production program to another; and so on.

What would be the common objective in the post-war world? It would be easy to agree on such general and vague goals as peace, security, full employment, the maximum welfare, and so on. But can these be translated into tangible aims for which each and every participating nation will be willing to make the sacrifices necessary?

These difficulties are well illustrated in the raw materials field. We should all agree in a general way that we want low prices for consumers, reasonable profits for efficient producers, and opportunity for employ-

ment for the workers of the producing countries. This is about the end of the agreement so far as I can see. One group would argue that the way to achieve these goals is by having a minimum of formal cooperation, the way to low prices and maximum employment being through the free play of competitive markets. At the other extreme are those who would argue that very detailed and close cooperation between governments is necessary to avoid the chaos that would result from unbridled competitive forces, particularly in the immediate post-war years. With these differences of opinion, it will be difficult to make even a beginning at international planning and cooperation when the procedures of war-time planning can no longer be justified. Assuming that these initial differences can be overcome and that international planning is attempted, there will still be countless clashes of national and business interests to be reconciled before agreement can be reached in any particular case.

The second condition making the work of the Boards relatively simple has been their limited membership. On the Combined Raw Materials Board, only the United States and the United Kingdom are represented, although a sister agency, the Joint Materials Coordinating Committee, brings Canada into a working partnership with the United States on raw materials problems. On certain of the other Combined Boards, Canada is also represented. Obviously, three-country representation is undemocratic. It can be defended only by the exigencies of war and the need of having an effective, compact organization among the major suppliers of war goods. In a post-war democratic organization, can forty-odd nations be effectively organized to provide for quick decisions with a minimum of disagreement?

A third condition which has facilitated the work of the Boards arises from the fact that it has been relatively easy to secure cooperation of all nations, even those not represented on the Board. It has been one of the Board's functions to increase production to meet expanded war-time demands. A producing country is likely to give its full cooperation under these favorable conditions. Would it do so equally well if international agencies were forced to take action that might cut that country's output or create for it serious problems of readjustment? Although seldom needed, the Board has also been able to use the weapons of shipping allocations and other sanctions, a normal part of war-time activities, which it would be difficult to impose in peace time.

It is well to reflect upon another point. The governments concerned have been able to take whatever steps have seemed necessary to gear their economies to the needs of total war. The machinery has therefore existed to implement the Board's activities. A good many of the Board's

allocations have assumed public purchase in foreign markets rather than unrestricted purchase by private traders. Much of the development work has been by public rather than by private enterprise. The Board's recommendations regarding conservation have been implemented by the full weight of the drastic war-time controls available to participating nations. These domestic controls and this willingness to sacrifice private enterprise if necessary will disappear when peace comes, at least in this country.

The Governments of the United Nations are now tackling the problem of constructing an international order which will make economic as well as political sense in the years after the war. They are aware of these difficulties and are undoubtedly taking them into account in their discussions. I shall not attempt to offer any suggestions as to how the difficulties mentioned can be overcome. I will say only this in conclusion. There is no simple and painless way to effective international cooperation, economic or politic. There must be commonly agreed and clearly defined objectives, effective organization, and willingness to sacrifice to some extent national interests for the benefit of the international body economic and politic. The Combined Boards offer some suggestions, but they certainly indicate no easy and painless solution to the problem.

ORGANIZING STATISTICAL WORK ON A FUNCTIONAL BASIS

By Harvey E. Becknell
U. S. Bureau of Labor Statistics

Nearly all statistical agencies of the Federal Government have been affected in one way or another by the war effort. For a few it has meant a curtailment of activities, but for many the statistical requirements of wartime policy making and administrative agencies have created an unprecedented expansion of data collection, processing and analytical facilities. These wartime demands have also sometimes necessitated considerable changes in the program and organization of the older statistical agencies. An adequate evaluation of the effect of the war on these agencies will require an exhaustive study in the post-war period. Case studies of the program and organizational changes made by specific agencies may, however, be of immediate interest and may contribute to a later general appraisal. It is from this point of view that the functional plan of organization, which has been adopted by the Prices and Cost of Living Branch of the Bureau of Labor Statistics, is presented in this article.

The term "functional organization" is used here primarily to designate a plan of operations in which the functions of program management are separated from those of research and in which these functions are handled centrally for the organization as a whole. In the case of the Prices and Cost of Living Branch, the term is also used to connote a separation of the functions of basic commodity price research and analysis from those of index number construction.

Developments leading to reorganization.—Up through 1940 the Prices and Cost of Living Branch carried on its work with a relatively small central office staff and with no field organization. Data from primary sources were collected by field representatives travelling out of Washington assisted by locally employed part-time personnel, or through mailed questionnaires. The planning and analysis work in the central office was conducted through three divisions, namely, Wholesale Prices, Retail Prices, and Cost of Living. Each division had its own statistical processing units, managed its own data-collection work, and handled the various stenographic and administrative services required by its own operations. General coordination of the work of the Divisions was effected through the Office of the Branch Chief. Such expansion of the Branch's work, as occurred prior to our entry into the war, was handled largely by additions to the staff of the then existing Divisions. However,

the tremendously increased volume of work which the Branch was called upon subsequently to do by the various war agencies, created organization and management problems of considerable magnitude. An idea of this increased volume of work may be gained from the fact that the total amount of funds available to the Branch for its regular work together with that for special services to the war agencies in 1943 was about five times the amount of its appropriations in 1940.

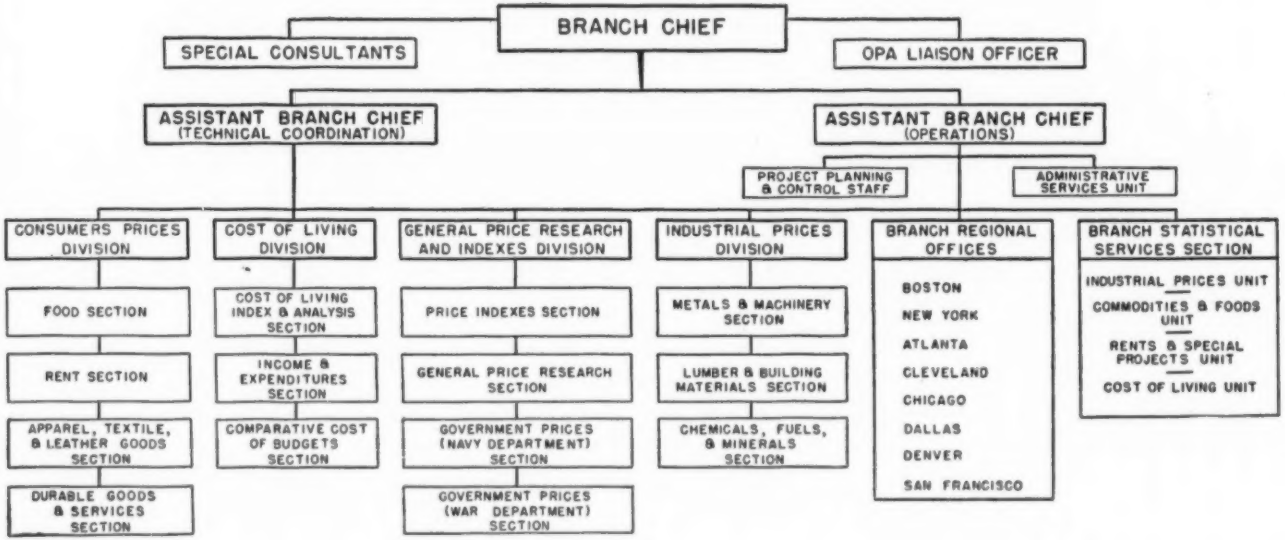
The Branch first attempted to meet the technical and operating problems growing out of this large expansion of its work by adding a new Division called the Price Analysis Division. This Division was staffed to handle exclusively the work for the Office of Price Administration and other war agencies. The Division grew very rapidly and soon had a full complement of commodity price sections, special index and research units, and an administrative services unit. It also found it necessary to establish regional offices, and, for a time, had some state and district offices. This field organization was required in the main to supervise large-scale surveys and to handle special studies and statistical advisory services required by the Office of Price Administration. Later on special price index work, which the Branch was called upon to do for the Navy and War Departments, was also placed under the general supervision of the Price Analysis Division. For a while this plan of organization for handling the increased work for the war agencies operated very successfully. As the program developed and as greater calls were made upon the data and staff resources of the older Divisions in connection with the Branch's work and for the war agencies, it became clear that a closer integration of this work with the regular program of the Branch was needed. With each Division having its own data-collection and statistical processing staffs, it was not possible to utilize personnel effectively to meet peak loads. Furthermore, the time of the central office professional staff was occupied too greatly with the details of administrative management and it was, therefore, not possible for them to give full attention to the development and direction of the research program in general and to the index work in particular. Likewise, altogether too little attention was being given to other management problems growing out of large-scale operations, such as personnel selection and technical work training, the preparation of annual and special budgets, project cost estimating and cost accounting, work simplification and procedure preparation, work progress reporting, and the analysis and scheduling of the work load.

Organizing on a functional basis. —Faced, therefore, with the problem of improving technical coordination and program management, the Branch decided to functionalize its work. The organizational structure which emerged from this decision is shown in the accompanying chart. Technical coordination was achieved by establishing the position of an

U. S. BUREAU OF LABOR STATISTICS

PRICES AND COST OF LIVING BRANCH

ORGANIZATION CHART



Assistant Branch Chief to handle difficult technical problems and procedures, particularly those of an inter-divisional character; to serve as expert consultant on broad problems of prices and program policy affecting the work of more than one Division; and, to act as general liaison officer with other agencies on such matters. The program of research work on prices and commodity problems was also strengthened by centralizing all research along commodity lines. This was done by creating two commodity divisions—the Consumers Prices Division and the Industrial Prices Division— in each of which was concentrated full responsibility for all market analysis concerning a given commodity from the wholesale through the retail level. The initiation and construction of index numbers, which cut across commodity and divisional lines, was put into the hands of two groups of specialists—The General Price Research and Indexes Division and the Cost of Living Division. These four Divisions, with the sectional organizations shown under each in the accompanying chart, became responsible for the over-all planning and technical supervision of all of the Branch's activities in their respective fields. This included the work undertaken for the Office of Price Administration and other war agencies, as well as the regular program of the Branch. Because of the large amount and wide variety of statistical work which the Branch is doing for the Office of Price Administration during the war, a special position of OPA Liaison Officer was established to assist in coordinating the work program for that agency. As shown in the chart, provision was also made for special consultants attached to the Branch Chief's Office to advise on specific policy and technical matters.

Under the new plan of organization all program management functions were centralized in a Branch Operations Office under the general supervision of an Assistant Branch Chief for Operations directly responsible to the Branch Chief. The field staffs of the former Price Analysis Division and the field representatives formerly travelling out of Washington were merged into one unit in the Branch Operations Office and were organized under Regional Price Economists responsible to the Assistant Branch Chief for Operations. Likewise, all clerical activities and administrative services were centralized in this Office. The Assistant Branch Chief for Operations was given general authority to act for the Chief of the Branch in the management of the entire work program and full responsibility for the direction of all data-collection and statistical processing operations required by the several Divisions of the Branch. The Assistant Branch Chief for Operations advises the Division Chiefs on the organization of proposed projects and represents the Branch on all project management matters with other agencies for which the Branch performs services. It is also the responsibility of this officer to direct the analysis and scheduling of the

work load and to determine priorities for the performance of all projects in the central office and in the field. He likewise is responsible for supervising the preparation of budgets, project cost estimates, and personnel requirements, and operating procedures.

Inasmuch as the work of the Prices and Cost of Living Branch is an integral part of the Bureau of Labor Statistics it is essential that many of the functions of the Branch Operations Office be performed in close collaboration with the Bureau's Business Management Branch and its general field organization. Experience under the new organization indicates that centralized handling of Branch Operations has facilitated clearances and expedited arrangements with these and other parts of the Bureau and with outside organizations.

How a functionalized statistical organization operates.—The unit of operations and control in the Prices and Cost of Living Branch, under the functional form of organization, is the project. Prior to the beginning of each fiscal year, the various Divisions prepare project proposals, similar to those prepared in budget making, covering their basic program of activities for the ensuing twelve months. Each proposal includes a statement of the purpose of the project, its justification, scope of work, working plans, anticipated results, estimated costs and personnel requirements. The proposal also includes an estimate of the time schedule for the performance of the project. These projects, when taken together, provide the basis for determining over-all staff needs for each of the Divisions and for the various data-collection and data-processing units. Likewise, time schedules and priorities for field work, statistical processing and other operations can be determined for the program as a whole from these project proposals. As new work develops during the year it is also formulated into new or supplementary project proposals and is scheduled for inclusion in the operating plans of the Branch.

Operations under the functionalized organization can be understood best by tracing briefly the course taken by a typical project. For purposes of illustration let us say that the Consumers Prices Division determines that a special survey of food prices at the retail level in selected areas is needed. After proper clearance with the Branch Chief, or Assistant Branch Chief in charge of technical coordination, as to general program policy, the Division Chief directs the Food Section staff to develop technical plans for conducting the study. These plans are formulated into a project proposal which is transmitted to the Branch Operations Office for calculating costs and personnel requirements and for determining the most effective methods of operation. When the proposal has been completed and approved, it is assigned an identification number and is scheduled for operation. The identification number is used by all employees working on the project for pur-

poses of time reporting. When the scheduled time arrives for launching the project, forms, instructions and other materials are transmitted by the Branch Operations Office to the data-collection staff in the field offices and to the Statistical Services Section in Washington. During the course of data-collection and statistical processing work the staff of the Food Section handles all questions of technical procedure by communications to the field offices and the Statistical Services Section transmitted through the Branch Operations Office. When the data have been assembled from the field offices and processed by the Statistical Services Section, they are transmitted in tabular form to the Food Section for analysis and interpretation. Current work progress reports are made by all operating units which show the status of the work on the project at all times and which provide a means of administrative supervision and control. Through the time reports prepared by the staff working on the project and an analysis of non-labor expenditures it is possible to determine periodically the actual cost of the work and to check it with estimated costs. These cost data also become increasingly useful in preparing cost estimates for future projects of the same or similar types.

The foregoing brief account of operations includes only the formal work steps in a functionalized organization. Obviously many decisions on major program and policy questions are arrived at through staff meetings. Frequent informal conferences are also employed in handling day-to-day work problems.

Conditions essential to successful operation.—In conclusion, the experience of the Prices and Cost of Living Branch has indicated certain conditions which are basically essential to successful operations under the functionalized form of organization. Chief among these conditions is general acceptance and consistent observance of the principle of advance planning of all work in terms of specific projects. Related to this and of equal importance is the preparation of and adherence to written operating procedures for all major steps in the performance of the work. Each operating unit must know specifically what it is to do, how the work is to be done, when its part is to be completed, and how the functions it has to perform relate to other units and to the undertaking as a whole. These conditions cannot be achieved without the complete understanding and whole-hearted cooperation of the entire staff. It is essential that the research personnel responsible for developing the program be management-minded, and that those responsible for the operating functions have not only a high degree of skill in administrative management but also possess considerable knowledge of research and statistical methods.

THE SAMPLE CENSUS OF CONGESTED PRODUCTION AREAS*

By Howard G. Brunsman
Bureau of the Census

The committee for Congested Production Areas was established by the President in April 1943. The Committee was instructed to designate congested production areas in order that the successful prosecution of the war could be promoted by providing more effective handling of Federal, state and local problems. Among the most acute problems of these congested production areas are the determination of the needs of the areas for hospital facilities, for butter, for children's underwear, and for a wide variety of other civilian goods. A suitable yardstick is required to measure the needs of each of these areas. Data from the Sixteenth Decennial Census in 1940 have been used for this purpose. These congested areas, however, have shown spectacular increases since 1940 and the census data do not supply a proper measure of the present need. The amount of the particular item that was consumed in a previous period is another possible measure. In many cases these amounts are not available and in those cases where they are available they fail to represent the current needs of the area. The count of applications for ration books in the area has been used to measure demand. The Census Bureau has prepared population estimates for each county of the United States based on these ration book figures. There are differences of opinion concerning the coverage of these data and their comparability with population figures obtained in a census. Because of these differences of opinion they are not always acceptable as measures of the needs of the area. A complete census of the population of the area would answer the questions and would supply a proper yardstick. The manpower shortage in each of these congested areas makes a complete census impractical. After a review of all of the various possibilities, the Committee for Congested Production Areas requested the Bureau of the Census to conduct a sample census in certain designated areas in order to determine the total population and the characteristics of the population of each area. For the purposes of this census the Committee defined each area as a county or as a group of contiguous counties.

Sample surveys are not new. They have been used successfully to

* Presented before the Joint Regional Meeting of the American Statistical Association and the Institute of Mathematical Statistics, Washington, D. C., May 7, 1944, with modifications based on results of the census that became available after May 7.

measure the number of persons employed and the number unemployed in the United States as a whole. All of you are familiar with the results of the survey that is conducted each month by the Special Surveys Division of the Bureau of the Census. Since this survey produces figures for the United States as a whole it is able to take advantage of the total population figure which can be derived from the 1940 population count with adjustments for births, deaths, immigration, and emigration since 1940. The field survey is used primarily to determine the relative number of persons in each of the various labor force groups. Sample surveys also have been used to measure conditions in local areas when the important consideration is the relative number of persons or the relative number of dwelling units with a particular characteristic. The occupancy surveys conducted by Special Surveys Division of the Census Bureau are excellent examples of surveys of this type.

The unique feature of the Sample Census of Congested Production Areas is the requirement that this census measure the total population with a relatively high degree of accuracy for comparatively small areas. In its most elementary terms the procedure which has been developed consists of determining the number of dwelling places in an area, next determining the average population per dwelling place, and then multiplying the number of dwelling places by the average population to secure a total population for the area. The principal steps to be performed under this procedure are: first, the listing of all dwelling places in the area; second, the selection of a sample of these dwelling places for enumeration; third, the enumeration of the selected sample of dwelling places in order to determine the number and characteristics of the population in these selected places; and fourth, the tabulation of the results in order to secure the estimates for the area as a whole.

There are two extremes that might be followed in the listing process. At one extreme, we might list each structure in the area as one dwelling place. On this basis a 300-room hotel and a 500-family apartment building would each be listed as one dwelling place. It might make a considerable difference in the resulting population estimate if a dwelling place of this type were included or excluded from our selected sample. The sampling experts rejected this approach because of the resulting wide variation. At the other extreme, we might list each dwelling unit in the area as a separate dwelling place. In order to be certain that we had skipped none of the dwelling units it would be necessary to knock at each door and determine the exact number of dwelling units located in each structure. This procedure would involve a tremendous amount of work. Ultimately, we decided on a compromise between these two extremes. For purposes of the census a structure that appeared to con-

tain not more than three dwelling units was listed as one dwelling place. Each dwelling unit in a structure containing four or more dwelling units was listed as a separate dwelling place. The listers were able to determine by inspection that most structures did not contain more than three dwelling units and it was necessary to ring very few doorbells in the listing process. Each room in a hotel or in a larger lodginghouse was listed as a separate dwelling place. After the listing process was completed, a sample of the listed dwelling places was selected and indicated on the listing forms. A dwelling unit schedule was prepared for each of these designated units and the dwelling unit schedules were assigned to enumerators for enumeration of all occupants of the designated places.

A special procedure was followed in institutions. The enumerator obtained lists of all occupants of each institution and selected a sample of these occupants for whom he obtained more complete information. The listing and enumeration processes were also combined in the enumeration for trailer camps. This combination was found necessary because of the high mobility of the trailers. If the processes had been separated the enumerator would find that the designated trailers had been moved since the date of the listing.

The sampling experts were faced with the problem of deciding what portion of the listed dwelling places were to be included in the enumeration. It was decided that a sufficiently large group should be enumerated so that the average error in the estimate of the total population of the area would be one per cent. On this basis, there is only a very small probability that the error in the estimate of total population will be as much as two per cent. On the basis of this criteria it was decided that enumeration would be required for one in five of the dwelling places of Charleston, for one in seven in Mobile, one in fourteen in the Hampton Roads area, one in fifteen in the San Diego area, and for one in twenty-three in the Portland-Vancouver area. This sampling procedure yields approximately 8,600 dwelling units in the sample for Charleston and 9,300 in the sample for Portland-Vancouver.

The listing of the 43,000 dwelling places in Charleston cost approximately half as much as the enumeration. The listing of the 210,000 dwelling places in Portland-Vancouver cost twice as much as the enumeration in that area. If all dwelling places in the Los Angeles area had been listed, the listing of the 700,000 dwelling places would have cost twelve times as much as the enumeration. Because of this high listing cost in Los Angeles and in the other large areas, an alternative procedure was developed. As indicated above the listing process serves two purposes; it yields a measure of the total number of dwelling places in the area and it supplies a group from which a representative sample of

the dwelling places may be selected. The sampling experts studied this problem and decided that both of these purposes could be served in the larger area without listing all of the dwelling places in the area. For cities of 50,000 or more the Census Bureau had prepared tabulations of the data obtained in the 1940 Housing Census by city blocks. This tabulation includes the number of dwelling units in each block. Special studies have been made of the change in number of dwelling units in the various blocks of a city. These studies indicate that the most rapid change occurs in the blocks that were vacant at the earlier period. This more rapid change is obvious. The unoccupied land in the vacant blocks offers the greatest chance for expansion. A study of all of these data led to the development of the following procedure: Occupied blocks in cities of 50,000 inhabitants or more were arranged in groups based on number of dwelling units in 1940 and on location of the block within the city as indicated by census tract number. Every Nth block was selected from the block groups after they had been arranged in this order. Dwelling places located in these selected blocks were listed. The listing process also was performed for all blocks which were vacant in 1940 and for all blocks outside the larger cities for which no 1940 data by blocks were available. After the listing process was completed a sample was drawn from the listed dwelling places. In drawing this sample an allowance was made for the difference in coverage in the occupied blocks of the cities and in the outlying areas. For example, in the Los Angeles area the listing of dwelling places was performed for one-seventh of the blocks that were occupied in 1940 in the larger cities. A sample of one-eleventh of these listed dwelling places was selected for enumeration. For blocks with no dwelling units in 1940 and for areas outside the larger cities all dwelling places were listed and a sample of one-seventy-seventh of the listed dwelling places was selected for enumeration. Thus, the same ultimate sampling ratio of one in seventy-seven was used for all areas in the city.

It is obvious that the estimate of the number of dwelling places in the area based on a selected sample of blocks will not be as accurate as the count of all dwelling places in the area. The resulting error in this estimate is extremely small because of the stratification of the blocks on the basis of the 1940 data and because of the complete listing of dwelling places in the vacant blocks of 1940 and in the outlying areas, where the greatest increase occurred. To offset this error in the estimate of number of dwelling places in the city, we increased the size of the sample of dwelling places selected for enumeration. Thus, the less accurate measure of the number of dwelling places in the area multiplied by the more accurate measure of population per dwelling place

leads to a measure of total population of the same accuracy as would be obtained with complete listing of all dwelling places and the enumeration of a smaller sample of the listed places. The increased sample included in the enumeration resulted in a total of 9,700 dwelling units for the enumeration of the Seattle area, ranging to 17,000 for the San Francisco area.

The main objective of the sample census is the establishment of an accurate population estimate for each area as a whole. This population figure should be comparable with the 1940 population figure. At the same time it must be recognized that these areas now contain a large number of visitors who would not be counted in the population of the area if we used the 1940 approach. These visitors include families of soldiers and sailors and other persons who are in the area only temporarily. To get complete coverage we instructed the enumerators to include anyone whose usual place of residence was in the selected dwelling place and anyone who slept in the dwelling place during the last twenty-four hours. By means of supplementary questions we determined which of these persons were residents of the area and which were visitors and also which of the persons were present during the past twenty-four hours and which of the usual residents were absent.

A "household" type of schedule was used in the enumeration process. Characteristics of the dwelling unit as a whole are shown in the heading of the schedule. Data relating to each individual in the dwelling unit are shown on a separate line in the body of the schedule. Extra dwelling unit schedules are used when an assigned dwelling place contains two or more dwelling units. This type of schedule is particularly well adapted to the census because of our method of assigning dwelling units for enumeration. The standard basic population data are obtained for each person enumerated in the census. These data include relationship to head, sex, color, age and marital status.

There is considerable interest in the extent of migration into these congested areas. Few data regarding this migration are now available. In order to throw additional light on this subject, the schedule includes a series of questions relating to place of residence of each person on April 1, 1940. The series of questions includes the name of the state in which the person lived in 1940. If the person lived in the same state in 1940 and in 1944, he was asked to report his county of residence in 1940. On the basis of this additional question we are able to identify those persons who moved into this congested area from elsewhere within the state since 1940. In order to determine the extent of migration from farms into the area a question is included on whether or not the person lived on a farm on April 1, 1940.

The schedule also includes a series of questions relating to the labor force status of each person 14 years old and over. The labor force questions utilize the so-called "sifter" approach that was used in the 1940 population census and which is now being used in the Monthly Report of the Labor Force. For each person 14 years old and over the enumerator was instructed to ask "Were you at work for pay or profit last week?" If the answer to this question is "No," ask "Were you seeking work last week?" And if the answer to this second question also is "No," ask the reason for not seeking work. Five general reasons for not seeking work are specified, as follows: (1) Had a job or business but not at work because of vacation, temporary layoff, temporary illness, or other similar reason, (2) Permanently unable to work or too old to work, and (3) Attending school and without a job, (4) Engaged in housework at home, and (5) Not seeking work for other reasons such as retired, or voluntarily idle.

The results for five of the areas are now available. These results show a resident civilian population of 3,357,000 in the Los Angeles area, representing a 15 per cent increase over the population on April 1, 1940. The 1944 population of 1,841,000 in the San Francisco Bay area represents a 26 per cent increase over 1940, the 167,000 of the Charleston area is a 38 per cent increase, the 416,000 of the San Diego area is a 44 per cent increase, and the 234,000 of the Mobile area represents a 65 per cent increase. The separate figures for the parts of these areas show a consistent pattern of greatest relative increase in the part of the metropolitan district that is outside the central city of the area, and smallest increase in the part of the area that lies beyond the boundaries of the metropolitan district, with the increase of the central city ranging between these two figures. The only exception to this pattern is the large relative increase in the small portion of the Los Angeles Congested Production Area that is located outside the metropolitan district.

The part of the resident population which was reported to be absent at the time of enumeration ranged from less than 1 per cent of the total resident population of the Mobile area to 2 per cent of the San Diego area. Visitors in the areas represented less than 2 per cent of the population present in the Charleston area, and ranged to a high of nearly 3½ per cent in the San Diego area. Thus, the population present in each of the areas exceeded the total resident population, the excess ranging from less than 1 per cent to nearly 1½ per cent. It should be noted that all published figures exclude several groups that account for a substantial portion of the congestion in these selected areas. Among the largest of these excluded groups is the Army and Navy per-

sonnel living on military posts and members of the Merchant Marine living on vessels in the area. The published figures do not include persons working in the area but sleeping outside the area. Nor do they include the daytime visitors from outside the county who were in the area on shopping trips or personal business.

In addition to the five areas specified above the census will include the Portland-Vancouver, Puget Sound, Hampton Roads, Detroit-Willow Run, and Muskegon areas. The census is being conducted on a sample basis in all of these areas except the Muskegon area where a complete enumeration is being used because of the relatively small number of inhabitants.

The results of the census of the Mobile area give some indication of the types of information that may be obtained from the analytical tables. Since April 1, 1940, the white population of the area increased 88 per cent, as compared with an increase of only 25 per cent in the nonwhite population.

The number of children under 5 years of age in the Mobile area in 1944 was more than double the number of children of this age in 1940. In contrast, the number of males between 20 and 24 years of age increased only 18 per cent during this period. There were 12,537 more females than males in the area in 1944. This represents a ratio of 90 males to 100 females, as compared with a ratio of 94 males to 100 females in 1940. The change in the ratio of males to females for the area is most noticeable in the military age groups. For example, in the group 20 to 24 years old the 1944 ratio is 47 males to 100 females, as compared with a ratio of 86 males to 100 females for this age group in 1940.

The influx of workers seeking employment in Mobile shipyards and other war industries has almost doubled the area's labor supply. In the Mobile metropolitan district among the women 18 to 64 years old and over who had no children under 10 years old, the proportion in the labor force increased from 44 per cent in 1940 to 51 per cent in 1944. In contrast, for women with children under 10 years old the proportion in the labor force showed a decline from 17 per cent in 1940 to 15 per cent in 1944.

Migration into the Mobile area from other parts of the United States was responsible for practically all of the population increase since 1940. The excess of births over deaths has been almost entirely canceled by the induction of men into the armed forces during this period. At least one person out of every three living in the county in March 1944, had moved in since April 1, 1940. Most of the in-migrants came from nearby areas; 46.1 per cent came from other counties of Alabama, 46.4 per cent from other states in the South, and only 7.5

per cent from states in the North and West and from foreign countries. A little over one-fourth of the in-migrants reported that they lived on a farm in 1940.

The in-migrants differed considerably in their characteristics from the people who lived in the area before the war. Only one-seventh of the in-migrants were nonwhite, as compared with more than one-third of the nonmigrant population. On the other hand, in-migrants, who were divided about equally between males and females, helped to bring the ratio of the sexes more nearly into balance. The percentage who were married was about the same in the in-migrant as in the nonmigrant population 15 years old and over. Among the married men in the in-migrant group, however, 20 per cent were not living with their wives in contrast with only 6 per cent of the nonmigrant married men. While a great majority of the in-migrants had established separate living quarters, 13.6 per cent were lodgers living with private families and 6.6 per cent were living in lodginghouses, hotels, dormitory rooms, or institutions.

The number of occupied dwelling units in the Mobile area increased 59.1 per cent between April 1, 1940, and March 1944, as compared with the increase of 64.7 per cent in population; the lodger population and the number of subfamilies in the area showed a considerable increase.

The results of the census will provide similar information for each of the ten congested production areas. The complete set of materials will include a relatively extensive series of analytical tables for each of the areas. These ten congested production areas comprise 28 counties, and five independent cities. They contain more than 28,000 square miles and have an estimated population of more than ten million.

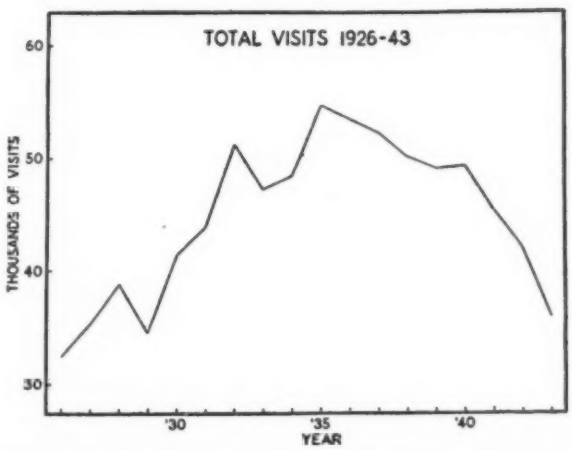
ANALYSIS OF THE DATA OF A PUBLIC HEALTH ORGANIZATION BY THE CONTROL CHART METHOD*

By Walter Schilling, M.D.
Stanford University School of Medicine, San Francisco

INTRODUCTION

The visiting Nurse Association of San Francisco is a corporate member of the National Organization of Public Health Nurses. Its activities include general and maternity nursing on a part time basis, prenatal classes and health supervision. In addition, services are avail-

CHART I



able to industrial policy-holders of certain insurance companies without extra charge. The organization is a member of the Community Chest.

Data showing the number of visits made by the Association each year are shown in Chart I. There is an obvious decline after the year 1935. The purpose of this paper is to discover the causes; also to describe the method used for analysis. The method is not hard to learn and undoubtedly has wide applicability in similar problems.

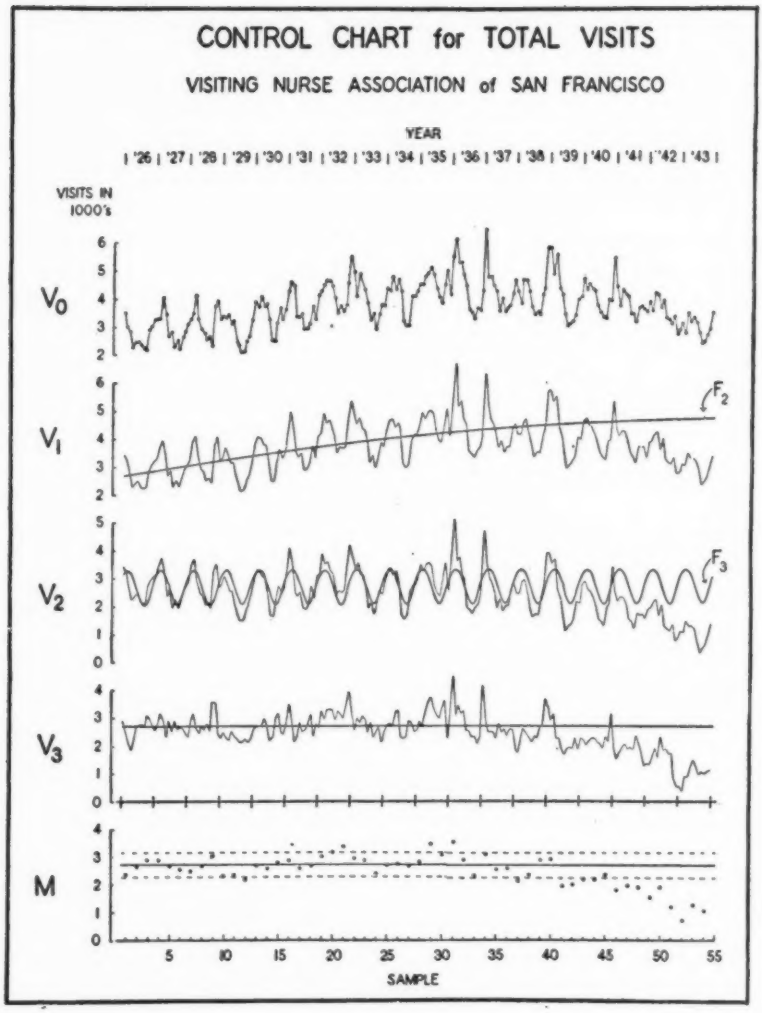
THE CONTROL CHART METHOD

As applied in industry, the method of quality control is designed to achieve a uniform result by discovering the causes of variation [1]. The

* I am indebted to the Secretary of the Visiting Nurse Association of San Francisco, Miss Aileen O'Brien, for aid in compiling these data, and to the Board of Directors for permission to publish them.

method was developed by Shewhart [2], [3], Deming [4], Simon [5] and others, primarily for the control of the quality of manufactured

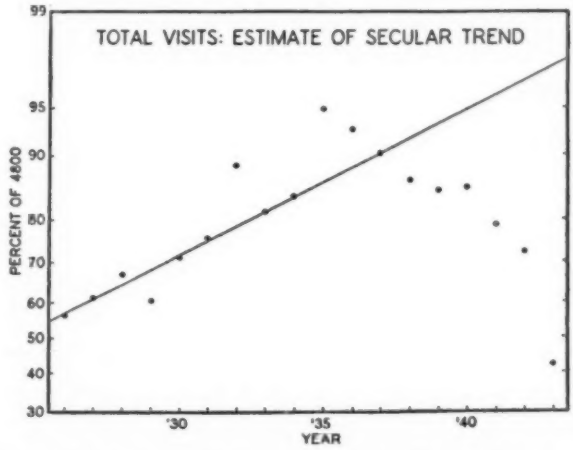
CHART II



products, and Rich [6] has recently used it in an analysis of the Columbia River salmon catch, as "it provides a convenient and rapid way of discovering the presence of heterogeneity in data, the causes of which on further study may be identified."

The ultimate purpose of such an analysis is action [7]. From the evidence presented by the data, standards are set up with which to determine the randomness of the process[1] under consideration. Deviations exceeding these standards, or "control limits," are then not the result of chance effects; they are not random, but originate in factors to which specific causes may be assigned. In the immediate problem, some changes in the number of visits may have their genesis in causes beyond the control of the organization, in which case no corrective action is possible. Other changes, however, may originate in disturbances of intra-organizational administration, for which the cause is then sought and, if discovered, action can be taken by the application of the appro-

CHART III



priate remedy. If the diagnosis has been correctly made, and the proper counter-measures instituted, succeeding deviations will remain within the limits set, that is, they will show the existence of a state of control.

PRELIMINARY ADJUSTMENT OF THE DATA

The raw data, total visits per month, are shown in Chart II, panel V_0. These are adjusted (F_1) to an average month of 30.42 days, the corrected values being plotted in panel V_1. Inspection of this panel indicates the influence of two additional factors, i.e., secular trend and seasonal variation. Both lend themselves to mathematical expression; their effects therefore may be removed from the data.

Correction for secular trend.—The trend is determined by making use

[1] For the purpose of this particular inquiry, "process" refers to the operational stability of the organization, measured in units of monthly visits.

of arithmetic probability paper [8]. The straight line fit (upper asymptote = 4800) is shown in Chart III. Eight of the first 12 points fall very nearly on the line. The remaining 4 can be disregarded, as the deviations which they show are the direct result of known economic factors which are not a part of the general trend, and which will be referred to later. The theoretical increase in monthly visits due to secular growth is shown as F_2 in panel V_1. The subtraction of these values results in panel V_2.

Correction for seasonal variation.—The cyclical movement remaining in panel V_2 is of the sine-cosine type. A standard cycle is calculated on the basis of the first 10 years according to the formula [9].

$$Y_c = \overline{Y} + A \sin [(360/T)X]^\circ + B \cos [(360/T)X]^\circ \qquad (1)$$

where

X = successive months of a cycle, i.e., 1–12

$\overline{Y} = \Sigma(Y)/12 = 2732$

Y is a specific monthly average over 10 years

T = length of cycle, in months = 12

$A = (2/T)\Sigma\{Y \sin [(360/T)X]^\circ\}$

$B = (2/T)\Sigma\{Y \cos [(360/T)X]^\circ\}$.

This works out to

$$Y_c = 2732 + 578.8 \sin (30X)^\circ + 272.50 \cos (30X)^\circ.$$

The calculated values are plotted as F_3 in Chart II, panel V_2. The necessary subtractions are made, and the residuals, now freed from the effects of three known causes of variation, appear in panel V_3 in proper form for the application of the control chart method.

APPLICATION OF THE CONTROL CHART METHOD[2]

The symbol X is used to indicate an observed value. Specific observed values, i.e., the number of visits in each month, are designated $X_1, X_2, \cdots, X_n$, where n is the number of observed values in a sample. As each of our samples includes the data for 4 months, $n=4$, any sample mean then may be written

$$\overline{X} = (X_1 + X_2 + X_3 + X_4)/n.$$

Thus the mean of sample 1 is

[2] For a detailed exposition, reference should be made to the publications of the American Standards Association [10], [11], [12].

$$\overline{X}_1 = (2912 + 2595 + 2158 + 1866)/4$$
$$= 9531/4 = 2383.$$

R is the range, the difference between the largest and the smallest observed value in a sample of n values. Thus

$$R_1 = 2912 - 1866 = 1046.$$

$\overline{\overline{X}}$ and $\overline{R}$ are the averages of a set of values of $\overline{X}$ or R.

The choices of the fundamental charts and subgroups of this study were somewhat forced by the manner in which the records were originally kept, units of one month being the smallest available. There is no reason, of course, why different choices should not be made in other investigations.

First analysis: total visits.—The mean and the range of each successive sample are calculated and the former plotted in Chart II, panel *M*. The ranges are not plotted, experience having shown that instances of lack of control in this study are always associated with causes that affect $\overline{X}$ rather than R. The mean range, $\overline{R}$, must be calculated, however, to provide a basis for computing the control limits of $\overline{X}$.

Inspection of the data indicates the advisability of using the first 10-year period (1926–35) for the determination of preliminary standards, on the basis of successive samples of 4 months each. Thus $\overline{\overline{X}} = 2723.7$ is the mean of the first 30 sample means, and $\overline{R} = 612.7$ is the mean of the corresponding ranges. A line is drawn in panel *M* over the period covered to indicate the level of $\overline{\overline{X}}$. The limits to be calculated represent two values of the variable, one above and the other below the grand mean, between which, under constant conditions, all of the sample means will fall *if* a state of control exists. Variations within the limits may be assumed to be due to "errors of random sampling." Points falling outside, however, in either direction would not result by chance oftener than about three times in a thousand observations, and hence may fairly be suspected of having assignable causes. Can such causes be determined, and are means at hand for taking corrective action?

Deviations above the upper control limit, representing an increased number of visits, may always be explained on the basis of unseasonable epidemics, increased relief work due to economic factors, etc. They only indicate that the activities of the organization were increased above the normal level, and thus give no occasion for action. We are more concerned with sample values falling below the lower limit, each of which demands explanation or action, or both. If explainable, and the cause is found to be beyond the control of the organization, it is enough to have attention called to the fact. However, lacking an ex-

planation based on an uncontrollable cause, trouble *within* the organization is indicated, and prompt investigation should be instituted. The purpose of the control chart, then, as applied to these data, is directed primarily toward the discovery of low values, thus samples exceeding the upper limit may, in general, be disregarded.

The preliminary estimate of the control limits are now made, following the procedure outlined in references [10], [11], and [12], q.v. As $n=4$, the following factors apply:

$$A = 1.500$$
$$A_2 = 0.729$$
$$d_2 = 2.059$$

and from these, the

$$\begin{aligned}\text{Control limits for } \overline{X} &= \overline{\overline{X}} \pm A_2\overline{R} \\ &= 2723.7 \pm 0.729 \times 612.7 \\ &= 2723.7 \pm 446.7 \\ &= 3170 \text{ and } 2277\end{aligned}$$

the level of the last values being shown as broken lines in panel *M* for the period 1926–35.

Do these preliminary standards properly represent the data? Three sample means fall outside the limits, but it is possible to assign uncontrollable causes to each. Sample 12 (1929.3) reflects[3] a decrease and 21 (1932.3) an increase in the number of free cases handled for the Community Chest, while 29 (1935.2) corresponds to a marked increase in visits originating in the state and federal emergency relief administrations. It would actually make no great difference whether these samples were disregarded or not, yet it was decided to discard them and to calculate new values for $\overline{\overline{X}}$ and $\overline{R}$. Now

$$\overline{\overline{X}} = 2695.2$$
$$\overline{R} = 618.8$$
$$\sigma' = \overline{R}/d_2 = 618.8/2.059 = 300.5$$

the last value being the calculated standard deviation of the universe sampled. On the basis of the standard values just adopted, the

$$\text{Central line for } \overline{X} \text{ is } \overline{X}' = \overline{\overline{X}} = 2695.2$$
$$\text{Control limits for } \overline{X} \text{ are } \overline{X}' \pm A\sigma'$$

[3] The figures in parentheses indicate the year and the third.

$$= 2695.2 \pm 1.500 \times 300.5$$
$$= 3146 \text{ and } 2244.$$

These now represent the final control limits for the sample means. The lines are transferred, as before, to panel *M* to cover a suitable future period beyond that of the preliminary data, i.e., starting with January 1936.

Inspection of panel *M* now shows that (a) sample 37 (1938.1), and (b) all the samples but one following 40 (1939.1) are out of control. The former gives a remarkable illustration of the sensitivity of this kind of analysis, when it is recognized that the assignable cause associated with this sample (which has been confirmed) was the failure of certain of the usual spring epidemics to make their appearance. This is indicated by the marked divergence of the monthly visits from the sine curve at this point (see panel V_2). The sequence following sample 40, however, shows such an increasing lack of control that the explanation must lie either in disturbances of internal organization or in external factors, or both.

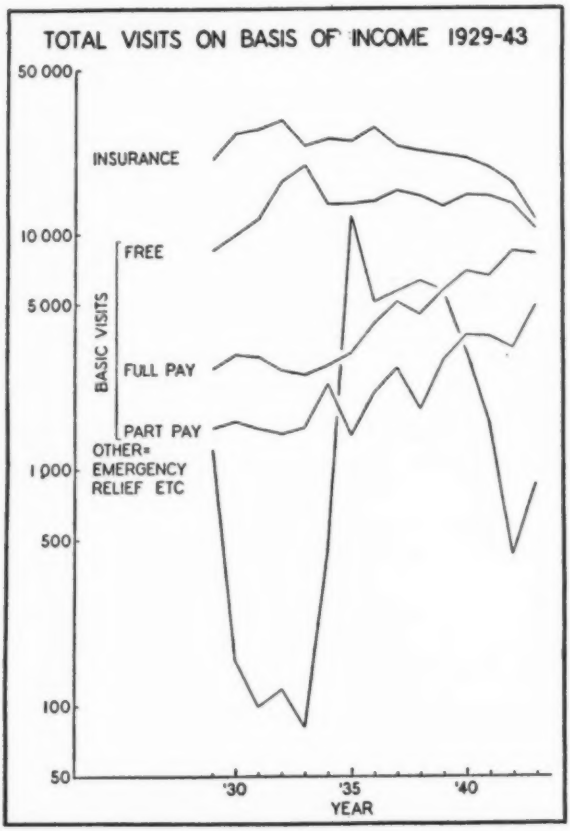
It should be noted here that panel *M* suggests a resemblance of cycles, but in general these remain within the limits of randomness. It is not surprising to find such an appearance, and its cause, as yet undetermined, is inherent in the residuals of the data and may well represent the effects of uncontrollable factors. A more detailed discussion will be given subsequently.

No explanation for the lack of control following sample 40 was disclosed, suggesting that the data were inadequate for the discovery of specific causes. Thus, to gain information, the monthly visits were broken down into a number of categories, based on source of pay. This disclosed two principal groups: (1) Basic, i.e., free (Community Chest etc.), part-pay and full pay; and (2) Contract, i.e., visits referred by insurance companies and by the state and federal relief agencies on a stated cost basis. The details are plotted in Chart IV. It will be seen at once that there was a steady decrease in insurance cases since 1937, due primarily to restrictions by one large company, while at the same time there was a great reduction in visits handled for the emergency relief administrations. The decrease in contract business clearly indicates one cause, at least, for the lack of control so far exhibited. As the acquisition of such business cannot be regulated by the Association, the monthly visits were recalculated on the more rational classification of basic visits alone.

Second analysis: basic visits.—Figures were not available, properly classified, prior to 1929. The revised data are charted in Chart V, which

follows the plan already given for Chart II. After correction to an average month (F_1), secular trend is recalculated on the basis of an assumed upper asymptote of 3000. The plot is shown in Chart VI, the

CHART IV



first three points representing the best estimates for the missing values. The fit is good when disregarding those deviations known not to be a part of the general trend, i.e., 1929, 1932–33. The correction for seasonal variation is applied, Formula (1) working out to give

$$Y_c = 1035.0 + 150.2 \sin (30X)° + 50.8 \cos (30X)°.$$

The averages and the ranges of the first 10-year period now give

$$\overline{\overline{X}} = 1035.0$$

$$\overline{R} = 239.5$$

and, as the sample size remains 4, the A and d constants are unchanged. Thus, the

$$\begin{aligned}\text{Control limits for } \overline{X} &= \overline{\overline{X}} \pm A_2\overline{R} \\ &= 1035.0 \pm 0.729 \times 239.5 \\ &= 1035.0 \pm 174.6 \\ &= 1210 \text{ and } 860.\end{aligned}$$

Lines representing these values appear in Chart V, panel M, to cover the period 1929–38; and it is apparent that 9 points now lie outside the preliminary limits. All of them were omitted in the calculation of the final standards, for (a) samples 20–23 represent greatly increased free work reflecting the depression (1932–33), (b) the low value for sample 28 (1935.1) is the result of a sharp decrease in part-pay visits which may be interpreted as an "offset" to the great increase in emergency relief during this year, and (c) the remaining 4 samples are only marginally out of control. The new values are

$$\begin{aligned}\overline{\overline{X}} &= 1002.4 \\ \overline{R} &= 255.1 \\ \sigma' &= 123.9.\end{aligned}$$

On the basis of the standard values just adopted, the

$$\text{Central line for } \overline{X} \text{ is } \overline{X}' = \overline{\overline{X}} = 1002.4.$$

The control limits for $\overline{X}$ are

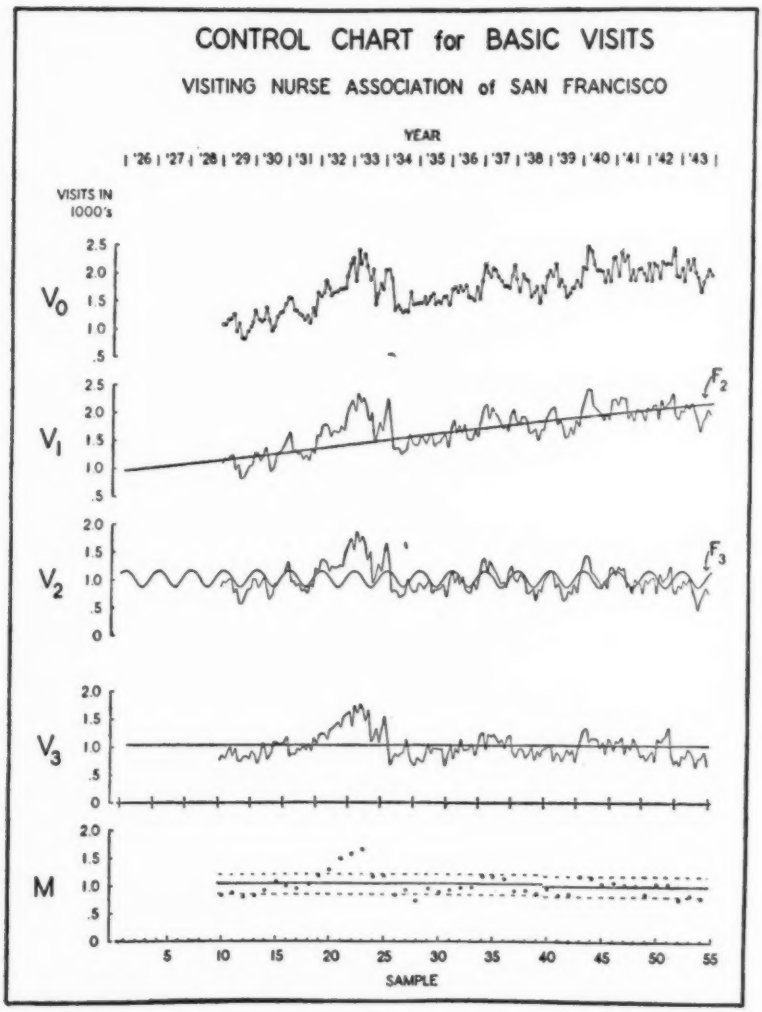
$$\begin{aligned}\overline{X}' \pm A\sigma' &= 1002.4 \pm 1.500 \times 123.9 \\ &= 1002.4 \pm 185.8 \\ &= 1188 \text{ and } 817.\end{aligned}$$

The central line, with its limits, is now transferred to Chart V, panel M to cover a period beyond that of the preliminary data, and, with the exception of two samples, both occurring in 1943, the "process" is shown to have been in a state of control. This justifies the division of the data into two groups, and shows that the decrease in total visits was due to a reduction of contract business.

It is necessary, however, to assign a cause, or causes, for the low values of samples 52 (1943.1) and 54 (1943.3). The deterioration was due to several factors. Because of the war, the year was marked not only by an excessive staff turnover, but by an actual shortage of nurses. This condition was aggravated toward the end of the year, when the pre-

vailing influenza epidemic affected the personnel as well as the public. Thus, the educational work of the organization was reduced, and, as

CHART V



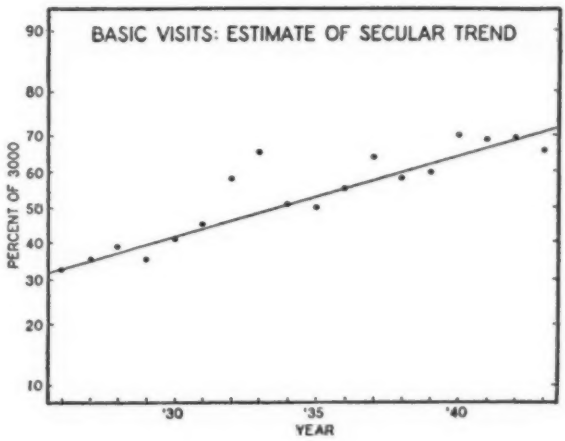
there is a direct relationship between such work and free visits, these decreased. Furthermore, because of the illness of the staff, the follow-up work also decreased, particularly during December. It may therefore be concluded, after taking into account the effects of the known causes

of variation on basic visits, and considering also the impact of a war economy on the organization, that the internal condition of the Association is sound.

DISCUSSION

The efficiency of the control chart as applied to the analysis of these data has been demonstrated. It remains, however, to refer again to the suggestion of cycles in the residuals (see panel *M* of Charts II and V). It was pointed out that while, in general, these remained within the

CHART VI



limits of randomness, they might represent the influence of uncontrollable factors. Reference is now made to the residuals in Chart V. While their cyclic character is not as marked as those in Chart II, there appear to be certain trends. Specifically, their direction and duration are thus:

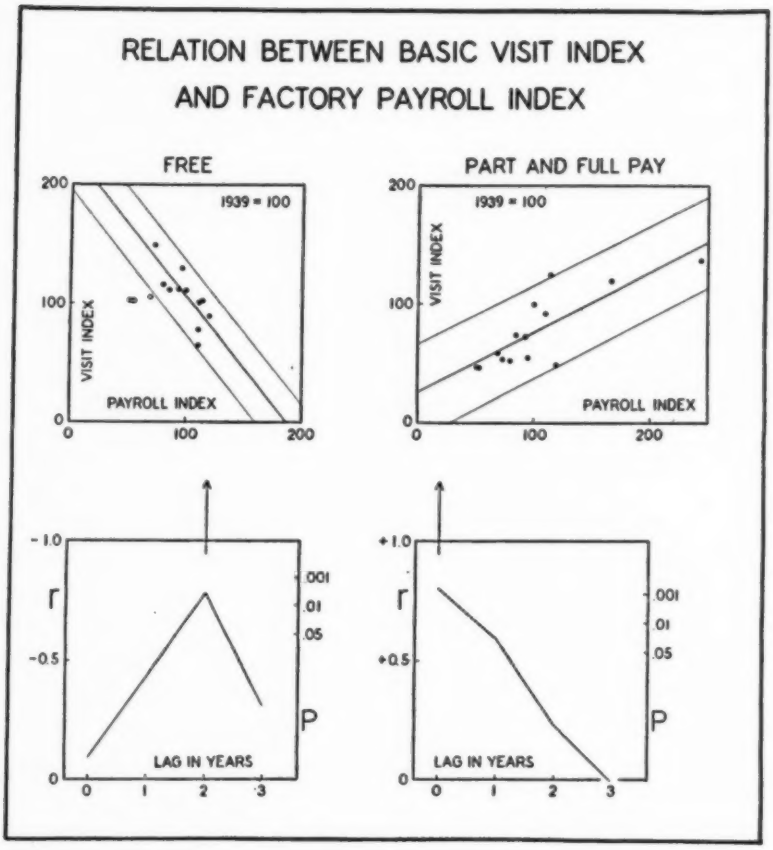
Upward: 1929–33; 1935–37; 1939–40

Downward: 1933–35; 1937–39; 1940–43.

It is generally recognized that an organization such as this is highly sensitive to changes in general economic conditions. In theory, a depression should result in an increase in free visits with a corresponding decrease in income-producing business. The reverse should hold true on the return of prosperity. In order to test this theory, which would explain part, at least, of the apparent residual cycles, use was made of the annual factory payroll index (1939 = 100) of the Federal Reserve

System [13]. It is not an ideal measure for the purpose, but has the advantage of continuity over the period covered by the data. An annual basic visit index with the same point of reference was prepared, and a

CHART VII



Regression lines with 95 per cent limits. Open circles in upper left panel represent abnormally low values due to government relief programs (1934–36) and are omitted from the calculations. r is the correlation between visit index and payroll index. P is the probability associated with r.

series of correlation coefficients calculated in order to discover (a) association between the two variables, and (b) the time lag intervening before changes in economic conditions were reflected in the business of the Association. The results are tabulated below, and are also shown in Chart VII.

Lag in years	Correlation coefficients (r)	
	Free visits	Part and full-pay visits
0	−.0893	+.8021
1	−.4278	+.5930
2	−.7828	+.2313
3	−.3148	−.0201

Chart VII appears to bear out the theory put forward. It is noteworthy that a lag of two years occurs before the maximum effect of a depressed economy makes itself felt in an increase in free business. Income-producing business, however, tends to decrease immediately as the payroll index falls.

The apparent cycles in the residuals are thus accounted for, and it should be pointed out as well, that the consecutive sequences of points above and below the averages in the *M* panels of Charts II and V, probably have the same assignable cause. Unfortunately it is not feasible to correct for this source of variation, as a correction cannot be applied to current data. Its importance lies in its effects on past performance, which make it possible to prognosticate the future with a greater degree of assurance. Thus, on the basis of experience, it would not be surprising to find a still greater decrease in free visits while the war lasts, the factory payroll index currently showing a marked upward trend. Income-producing business might compensate for this decline, but it must be taken into consideration that many of the income-producing patients are employed by the Federal Government and by the local shipyards, and are thus eligible for free nursing care elsewhere.

CONCLUSIONS

1. There has been a decline in the total business of the Visiting Nurse Association of San Francisco since 1935.

2. The decrease is due to a reduction in the number of contract cases handled, for

3. On removal of this segment from the data, it is shown that successive samples of four months each now either (a) remain in a state of control, or (b) have assignable causes beyond the control of the organization.

4. The activities of the organization are sensitive to changes in general economic conditions.

5. So far as its basic function is concerned, the Association is operating in a satisfactory manner.

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MATTERS OF MISCONCEPTION CONCERNING THE QUALITY CONTROL CHART

By Edward M. Schrock
Ordnance Research Center, Aberdeen Proving Ground, Maryland

During the early days of the war, the tank armor program was expanding rapidly. A combination of circumstances made it evident that a reduction in the amount of armor consumed by acceptance testing (which is necessarily destructive) would soon be necessary. The problem was to develop a sound basis for reducing the amount required from any given facility.

To provide such a basis, the Armor Plate Quality Control Plan was developed and put into operation by the Ordnance Department. The Plan is based upon the quality control chart for variables using averages and ranges for groups of four successive ballistic test results.

There are generally a great many practical considerations involved in connection with the application of a quality control chart to an industrial process and it is especially so in this case. Hence, a discussion of the Plan is beyond the scope of this paper.

The application here used has been comparatively new to a large portion of the people affected. As a result, a number of practical questions have been raised with reference to the suitability of the application and the interpretation of the quality control charts constructed. It will be the purpose of this paper to discuss some of the matters most commonly mentioned.

1. *There are too many variables in the manufacturing process.* Any process designed to produce successive items, all of which are intended to be essentially alike with respect to certain measurable quality characteristics, will involve a certain number of variables. As a normal minimum there will be at least four major variables—raw materials, process variations, personnel and extraneous factors such as weather, atmospheric conditions, breakdowns and power failures. Each of these major variables may in turn be broken down into as many subdivisions as the product involves.

For a comparatively simple process, the problem of determining the importance of each variable is not too difficult. As the process grows more complex, the need for statistical methods to evaluate the significance of results increases. In any case, statistical methods are invaluable in distinguishing among border line cases where the significance of obtained differences is not obvious.

In the application involved here, the objective is to make many pieces of armor at a satisfactory quality level, with all of the pieces being essentially alike. This is the very thing the quality control chart is designed to measure. Therefore, the number of variables in the manufacturing process is of no concern with respect to the suitability of the quality control chart for this purpose.

2. *There are too many changes made in the process from time to time.* Change in material things inheres in the fact that the minute particles that make up all matter are in constant motion and are subject to constantly shifting intra- and inter-atomic forces. The changes that occur in the material world vary all the way from the spectacular changes that occur in a fraction of a second to the virtually imperceptible ones that require many years for completion. The important thing is that with time, all material things change.

Efforts to establish a manufacturing process that will produce successive items all identically alike are futile. The possibility of two or more things exactly alike exists only in the mind as a concept and has no verification in human experience. Even if the portions of raw materials were identical, we would be defeated by the fact that the manufacturing equipment is subject to constant change. Friction, temperature fluctuations, and other constantly shifting chemical and physical forces continually alter the machinery used. The net result is that no two items ever come from identically the same process.

With sufficiently homogeneous raw materials and proper engineering design, it is usually possible to produce successive items that are nearly enough alike to function satisfactorily for the purpose intended. When such items are produced under the condition of statistical quality control, no further reduction in the amount of variability inherent in the process can be achieved unless fundamental changes are made in the nature of the raw materials or in the process. When operations are proceeding in this manner, the changes occurring in the process (whether readily detectable or not) are unimportant. When changes occur that significantly shift the quality level or variability of the product, this fact will promptly reveal itself on the control chart.

3. *The sample is not sufficiently representative of the lot.* It is generally agreed that sometimes the test plate does not properly represent part or all of the lot from which it comes. Therefore, the point of view of the Armor Plate Quality Control Program is that the test plate does not adequately represent the lot. It does represent the production process and enables us to determine whether the process is in control. When it is not in control, the likelihood of substandard material being made is

greatly increased. At such times it is highly desirable to increase the amount of testing done.

4. *The test method is not precise enough.* Methods of testing vary considerably in their precision. Unfortunately, the methods of testing the ballistic quality of armor are not as precise as we should like. However, the test methods used do enable us to distinguish various quality levels of armor. Further, they are considered suitable as a basis for acceptance and rejection. In general, we may state that any test method that is considered good enough to form a basis for acceptance or rejection of the material tested is suitable for application of the quality control chart.

5. *The method has never before been used for this application. How do we know it will work?* The point has been raised that the quality control chart technique has been in use only since 1924 and that this is the first time it has been applied in this manner to armor plate. After all, how are we sure its application here is sound? The answer to this question lies in the function of the quality control chart. That function is to measure the degree and sort of control existing in a repetitive process designed to produce successive items all essentially alike. Therefore, the mere fact that a specific application has not been made before need not be a matter of concern. The nineteen years the method has been in use have been far more than enough to establish its validity and reliability. They were established virtually from the beginning.

6. *With time, my ranges will decrease and I will eventually be forced out of control.* When production is begun on a new product, it is generally expected that some production difficulties will occur that will be cleared up as time goes on. It is also expected that some way may be found to improve the quality level of the product and to improve its uniformity. When a large number of manufacturers are all making the same sort of new product, it would be most surprising if some of them did not succeed in making this improvement. In line with these expectations, some armor manufacturers have succeeded in raising their ballistic quality level or reducing their variability to as much as about two-thirds of its original value.

As ways are found to improve the product, the production job may become more difficult. However, when a new level of quality or reduced variability has been established, the probability that a point will fall outside the new control limits just due to chance is the same as it was before. There never will come a time when the manufacturer will of necessity fall out of control just because he is making an improved product.

It is natural for the manufacturer to desire tolerance limits as wide as possible. This tends to make his job easier. The way to better quality, however, requires something more than mere maintenance of existing standards or close adherence to minimum standards of acceptance. Efforts to obtain wider control limits through the deliberate introduction of greater variability into the product are to be strictly avoided. The lack of randomness almost certain to be associated with such efforts will quickly reveal itself as a lack of control. In any event, the task will undoubtedly prove to be more laborious and costly than any so-called advantage obtained would justify.

In order to illustrate the relationship between changes in the cause system and quality control chart shifts in quality level and variability, three charts have been constructed using random numbers. A series of random numbers consists of digits so selected that each time one is chosen, one digit is just as apt to occur as any other digit (insofar as it is humanly possible to create this condition). The following is a series of 50 such numbers:

0 9 1 1 5 1 8 6 3 5 1 2 2 5 3 7 5 9 1 3 6 7 2 0 2

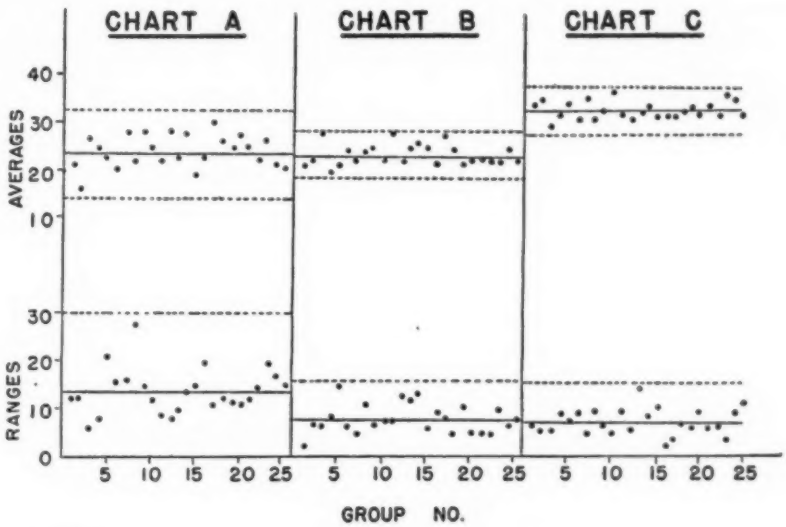
1 1 3 3 3 6 1 6 2 6 0 0 6 2 1 1 9 4 6 9 3 8 0 8 9.

Each five successive numbers were added together. The maximum possible number that could be thus obtained would be 45 (five 9's) and the minimum would be 0 (five 0's). These newly obtained numbers tend to closely approximate the normal distribution. One hundred numbers were accumulated in this manner. They were then grouped by successive four's and the average and range of each group of four determined. The expected grand average would be 22.5. Control chart limits were then calculated for the 25 groups in a manner similar to that used in the Armor Plate Quality Control Plan. The results are shown as Chart A.

The entire process was then repeated after all 0's, 1's, 8's and 9's had been removed from the original list of random numbers. The maximum number now obtainable would be 35 (five 7's) and the minimum would be 10 (five 2's). The expected grand average would still be 22.5 but the average range would be expected to be considerably smaller thus bringing the control chart limits on the chart for averages much closer together. The results are shown as Chart B.

The entire process was again repeated with only the 0's, 1's, 2's, and 3's removed from the original list of random numbers. The maximum number now obtainable would be 45 (five 9's) and the minimum would be 20 (five 4's). The expected grand average would now be 32.5 and

the average range would be expected to be virtually the same as that for Chart B. The results are shown as Chart C.



Calculated results:	Chart A	Chart B	Chart C
Grand average	22.83	22.69	32.29
Upper control limit	32.31	27.76	37.13
Lower control limit	13.35	17.62	27.45
Average range	13.00	6.96	6.64
Upper control limit	29.67	15.88	15.15
Lower control limit	0	0	0

The important thing to note in connection with the above charts is the fact that when significant shifts occurred in either quality level (as reflected by the grand average) or inherent variability (as reflected by the average range), it was due to a change in the cause system producing the results. When no change was made in the cause system, there was no significant shift in grand average or range. No matter how long a process continues, significant shifts are very unlikely to occur unless there is a significant change in the raw materials or in the manufacturing process. If, after a manufacturing process has continued for some time, a significant shift in quality level or inherent variability has occurred, the cause of the shift will sometimes be apparent. If it is not, the manufacturer should search diligently for the cause until it is clear that further search would not likely be profitable.

7. *It is possible to go out of control limits and get back in without doing anything to the process.* Quality level shifts that are of small magnitude

or of short duration can readily occur without immediately revealing themselves. Shifts may be gradual or sudden, uniformly in one direction or erratic, or controlled or uncontrolled. Any combination of these conditions may occur with any degree of intensity. Shifts that are of slight magnitude, but long duration may result in only an occasional point falling out of control limits. Thus, if the manufacturer makes no deliberate change in the process during this time, it appears to him that the process has gone out of control and gotten back into control without any effort on his part. The truth of the matter is that the process has probably not been in control at the previous level or with the same magnitude of inherent variability as previously at any time during the period involved.

The greater the shift that occurs, the greater will be the likelihood of a point falling outside control limits, the more serious the situation will be, and the more frequently increased testing will be required in the armor program. However, any point that falls outside control limits should be regarded as a danger signal and every effort made (within economically practicable limits) to determine the reason for the indication of lack of control. Only very rarely do indications of lack of control occur without there being an assignable cause.

8. *My control limits have shifted and now a point is outside control limits whereas formerly it would have been within limits. Why is this point not considered a satisfactory condition?* Each plotted point on the control chart tells a most eloquent story in relation to its own control limits. Thus two points widely separated on the chart might have the same numerical value, but very different meanings. Suppose the first of these points falls within control limits. We can only assume from this fact that the product is continuing to be made in a controlled manner. Before the second point with which we are concerned occurs, many other points are accumulated which reveal that control has been achieved at a higher level. When the second point occurs it may now fall below the new lower control limit. It signifies that control is probably not being maintained at the new level. Any indication of lack of control must always be regarded as a danger signal regardless of when or where the indication occurs. In addition to our interest in the point's numerical value, we are also interested in its position relative to the control limits which apply to it.

9. *Why is going above the upper limit for averages undesirable when we are working to a specification minimum? Is this not a great deal better than can be expected?* If the point that goes above the upper limit is preceded by a gradual upward trend of the group averages in what appears to be a controlled manner, there is little likelihood of defective

material being produced. If, however, a point suddenly jumps out of the upper limit without any forewarning, it most likely represents a condition of lack of control. When the manufacturing process is out of control, almost anything can happen, including a sudden drop in quality. Frequently, such high points are followed almost immediately by ballistic failures. While a high level of quality is desirable, it is also very important that control be maintained. Without control we cannot expect to have a uniform product.

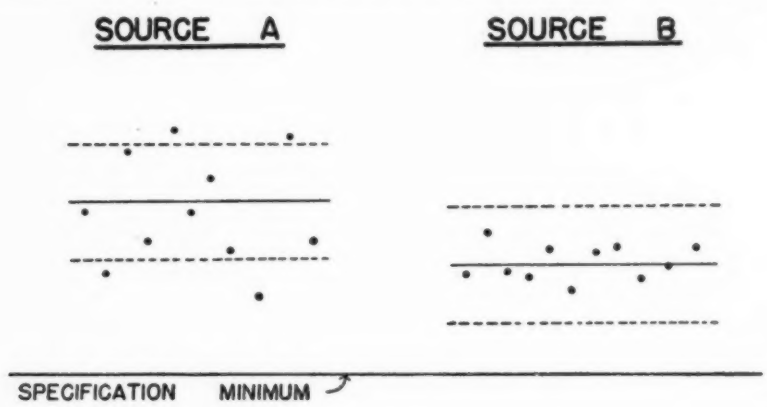
10. *If points for averages are permitted to go above their upper control limit to encourage shifts to higher levels, why are not points for ranges permitted to go above their upper limit?* The control chart in this application uses averages and ranges. The function of the averages is to reveal the level on which the process is operating. The function of the ranges is to reveal the amount of variability inherent in the process. The ranges do this independently of the process quality level and reveal nothing about its quantitative value. The average range, however, does enable us to establish the limits within which virtually all the group averages should fall. These limits are then placed above and below the process average quality level. Any given group average then indicates both a quality level and whether there is any indication of lack of control. Any given group range reveals both variability and whether there is any indication of lack of control. Thus, group averages that go above the upper control limit may possibly be the result of a gradually rising quality level, but a range that goes above its upper control limit can only indicate a lack of control.

11. *Is not an uncontrolled product at a higher level more desirable than a controlled product at a lower level?* While the average quality level of the process is important, the degree of control in effect at that level is also important, in fact vitally important. Without the existence of controlled operations, we can never be certain within what limits future observations will likely lie, within what limits untested material already made lies (the control chart is derived in this case from samples), or whether the existing level of average quality will be maintained.

In general, Source B would be definitely preferred to Source A, in spite of the fact that the average quality level shown for B is lower than for A. Since A shows several indications of being out of control, we cannot be sure that the average quality level shown is the true quality level for all material made during the period of time involved. Nor can we be sure as to the amount of untested material that would also fall outside the control limits, or what portion of it, if tested, would fall below the specification minimum, or what the future level or variability is apt to be. On the other hand, in the case of Source B, we have a high

degree of assurance that the quality average and variability of the untested material is essentially the same as that of the tested material, that extremely little, if any, of the untested material would fall below the specification minimum, and that the existing level and amount of variability probably will be maintained in the immediate future.

12. *What good is a control chart on a certain property if it is a different property in which we are interested?* This question has been raised by armor manufacturers who have had trouble with a different ballistic property (measured by an attribute testing method) than the one on which control charts are constructed. If the two properties are not re-



lated, such a chart will not be helpful. However, in the case of the armor program, it has been found that indications of lack of control tend very markedly to be associated with failures on other ballistic properties. Wherever the two properties are related, such a chart can be very useful.

13. *If the level of averages is high enough, is it not possible for a point to fall at least a little bit below the lower control limit without danger of ballistic failures?* A tabulation has been made for each point falling below the lower limit for averages according to the ratio of the number of standard deviations below the lower control limit as related to the number of standard deviations the lower control limit was above the specification minimum. Ratios as high as 138 were obtained. However, no level could be found at which freedom from the likelihood of some type of ballistic failure could be assured.

No failures for the property on which the control charts were constructed occurred above the ratio of 6.5, but other types of ballistic failures continued to occur at all levels.

14. *If one is interested in controlling a certain quality characteristic,*

should control charts be started immediately on all factors known or believed to affect the quality involved? Yes, if there are only a few factors involved, say two to four. No, if there are many. In the latter case it will be better to start with a control chart only for the quality characteristics it is desired to control. As indications of lack of control occur and causes are identified, control charts on causative factors may be added.

SUMMARY

1. Wherever the aim is to make many items all essentially alike, the quality control chart is applicable regardless of the number of variables in the manufacturing process.

2. It is also applicable regardless of the number of changes made in the manufacturing process from time to time.

3. It is also applicable regardless of whether the sample is adequately representative of any so-called "lot."

4. Any test method with sufficient precision to form the basis of acceptance or rejection of the material tested will be suitable for application of the quality control chart. In general, the amount of possible error in any individual test result should be small in comparison to the scale over which test results will normally vary.

5. The quality control chart is applicable to any process designed to make many items all essentially alike, regardless of whether any applications specifically comparable to the one in question have ever been made before.

6. Inherent variability in a type of product does not change significantly with the passing of time unless fundamental changes occur in the production process.

7. Any point that falls outside control chart limits indicates (with a high degree of probability) that a significant shift in quality level has occurred. Such indications may result from either a slight or large shift.

8. The significance of any point on a control chart (with respect to the degree of control it indicates), depends upon its position in relation to the control limits that apply to it.

9. A point falling above the upper control limit for averages must be regarded as a danger signal even if the only requirement is a specification minimum. It indicates an unstable process that may suddenly drop in quality level.

10. A point for ranges that falls above its upper limit reflects significantly increased variability in the product, a condition generally regarded as undesirable.

11. A controlled product at a somewhat lower quality level (provided minimum requirements are adequately met) is generally preferable to an uncontrolled product at a higher quality level.

12. A quality control chart based upon a certain quality characteristic can be helpful in gaining control of related properties.

13. No matter how high the average quality level may be, any point falling outside the control limits should be regarded as a danger signal.

14. In establishing a quality control program, control charts should first be constructed for the quality characteristic desired. Charts for causative factors may be added later as appears feasible.

INDUSTRIAL MATERIALS PRODUCTION, WORLD WARS I AND II*

By Geoffrey H. Moore
National Bureau of Economic Research, Inc.

The reliability of a statistical comparison of production in the two wars is inversely related to its scope. It is not difficult, for example, to get reliable and comparable data on the production, in each war, of certain more or less standardized commodities, such as bituminous coal, pig iron, and wheat flour. And it is possible, I think, to draw rather interesting conclusions from such data, which, while limited in scope, conform to rather strict standards of reliability and comparability. Inquiries of broader scope, which aim to compare total production, or total commodity production, or total industrial production, are beset by two sorts of difficulties. One has to do with the discontinuities in the sphere of production, the other with the availability of data.

If the object is to compare the level of total output at analogous dates in the two wars (say 1917 and 1942), then some method must be devised for dealing with the fact that many of the goods produced in 1942 were not produced in 1917, and vice versa. Similarly, if the object is to compare the rate of change in total output during analogous intervals in the two wars (say 1914–17 and 1939–42), then some method of dealing with the fact that many of the goods produced in the later years of each war were not produced in the early years, and vice versa, is called for. One possibility is to define individual commodities so broadly that the discontinuities disappear. In order to get a continuous series one might, for example, have to define one commodity "motor vehicles," and to include under that term 1940 model automobiles of all makes, 1943 model tanks of all types, 1915 automobiles, and 1918 tanks. A simple count of these vehicles, or some more sophisticated system of counting or weighting, would produce a "continuous" series. In any case, in view of the widespread changes between and during the two wars in the kinds of goods produced, some method of equating new and old commodities is vital to comparisons of total output. Moreover, it is important to recognize that any method is bound to be

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I wish to thank Johanna Stern and Karl Laubenstein for their able assistance in collecting data, and H. Irving Forman for his careful work in drawing the charts for this paper. I am deeply indebted to Arthur F. Burns for counsel at every stage of the inquiry.

unconventional, and hence require detailed specification if the results are to be understood.

These considerations would be even more important were it not for the fact that in many cases the data necessary to develop a given method do not exist. Some idea of the size of the gap in production statistics may be gathered from the fact that the direct coverage of Fabricant's index of manufactures, which is based on Census data, was only 55 per cent in 1914, 56 per cent in 1919, and 65 per cent in 1937.[1] Since there was no Census between 1914 and 1919, and none since 1939, the coverage of available annual data during the two wars is decidedly smaller than these figures suggest, although the wartime expansion of statistical inquiries undertaken for control purposes has tended to alleviate the situation. In any case, the gap to be filled if statistical comparisons of production in the two wars are to be comprehensive is large, and such attempts as have been made to fill it involve estimates of an exceedingly dubious character, as will be seen.

Truly comprehensive measures of production in wartime are, then, suspect on two counts. In the nature of the case they must employ definitions of commodities so broad, or methods of equating new and old commodities so arbitrary, as to be almost meaningless; and they must use estimates of production so flimsy as to be almost ridiculous. There is much to be said for the pursuit of a more modest aim—to learn what one can from data that are relatively homogeneous, continuous and reliable. The conclusions reached will not be global, but they will not be "globaloney" either.

Now the commodities for which homogeneous, continuous, and reliable data for the two wars are available are, for the most part, relatively unelaborated materials used in further production. Fabrication and differentiation are almost synonymous in practice. Such commodities as steel, copper, coal, cotton, and cement are basic materials in war as well as in peace, in this war as well as in the last. The statistics on the production or industrial consumption of these and similar commodities satisfy rather exacting requirements as to homogeneity and comparability, and in a sense, are comprehensive. For all fabricated products utilize materials of one kind or another, and for most of these materials statistics are available.

Because of their comprehensiveness in this sense, it seems worth while to compute an index from them, using value weights for products of domestic industry (minerals), and value added weights for products that originate outside domestic industry (in foreign countries or on

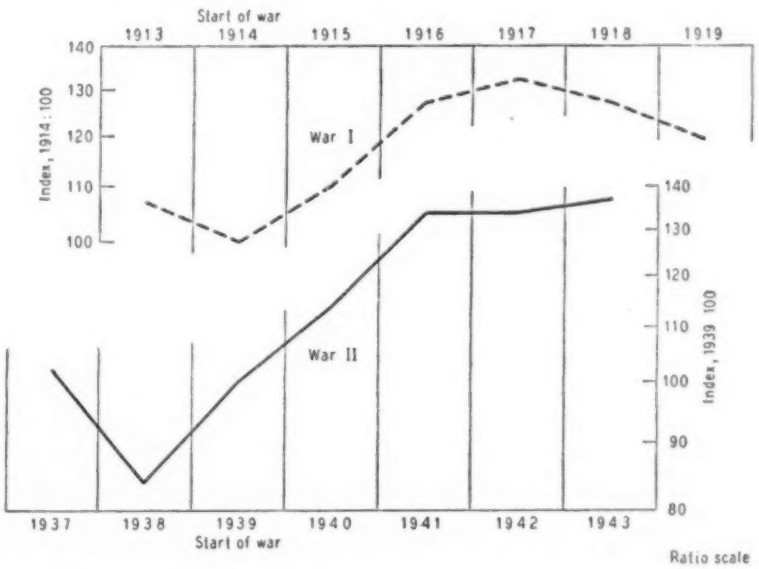
[1] Solomon Fabricant, *The Output of Manufacturing Industries, 1899–1937*, National Bureau of Economic Research, 1940, p. 602.

farms). Such an aggregate is not a well-defined total; its magnitude is determined primarily by practical considerations concerning the homogeneity of commodities and the availability of data. But for the purpose of wartime comparisons, and with all due qualification, it seems worth while to compute an index which represents a part of total industrial output that is both feasible to estimate and basic to the remainder, the more highly fabricated products.

In any case, such an index of industrial materials production has been constructed from data relating to 47 materials in both wars,[2] and is presented in Chart I. The salient features of the comparison are: (1)

CHART I

Industrial Materials Production, World Wars I and II



the output of materials was about 60 per cent larger at the start of World War II (1939) than at the start of World War I (1914);[3] (2) the production of materials expanded by similar percentages in both wars—around 30 to 40 per cent; (3) in both wars a rapid initial rise in production was followed by a period of relative stability—most of the increase

[2] *Cf.* Occasional Paper 18, *op. cit.*, p. 5. The World War II index presented here is based on revised data for the original list of series, and was computed with the assistance of Julius Shiskin of the Planning Division of the War Production Board, who adjusted the index to include confidential data. The revised index is (1937–43): 102, 84, 100, 114, 134, 134, 137.

[3] This is not indicated in the chart but is based on a recomputation of the 1914 index, using 1939 weights (*ibid.*, p. 5).

in materials output was achieved in the first two years of each war.

It is both a merit and a defect that this index is based on an identical list of materials in the two wars. The merit is that formal comparability is assured; the defect, that the result is biased. But the defect is tempered by the fact that the direction of the bias is clear: the use of an identical sample tends to reduce the rate of increase in the index in the second war relative to that in the first. This does not mean that the rate of growth shown by the index in World War II is actually too small; this would follow only if the rate of growth shown by the World War I index were either absolutely "correct" or too small. In other words, the actual rates of growth of the indexes during the two wars depend on the idiosyncrasies of the particular sample of commodities chosen; the fact that the sample is a constant one merely affects the relation between the rates of growth.

The magnitude of this effect, as well as the characteristics of the sample, have been discussed elsewhere.[4] Clearly, if the object had been merely to construct an index for World War II rather than to compare the two wars, the sample could have been improved. While it seems likely that such a revision would yield an index rising appreciably faster after 1941 than does the present one, this is not altogether certain.[5]

One reason for thinking that the comparison of the indexes in Chart I is not misleading is to be found in Chart II. The ten commodity series there depicted are a small but fairly representative sample of the type of series included in the index. It is evident that the similarity in behavior of the indexes in the two wars is, in considerable measure, the result of a general similarity in the behavior of individual commodities. The most prominent exceptions to this general similarity are lumber and cement, which advanced much more rapidly in the early years of War II than in War I, and aluminum, which advanced more rapidly in the later years of War II than in War I. But these exceptions do not mar the striking correspondence in average rates of change and in year-to-year behavior. In particular, the retardation shown by our index in the later years of both wars is seen to be rather widely diffused.

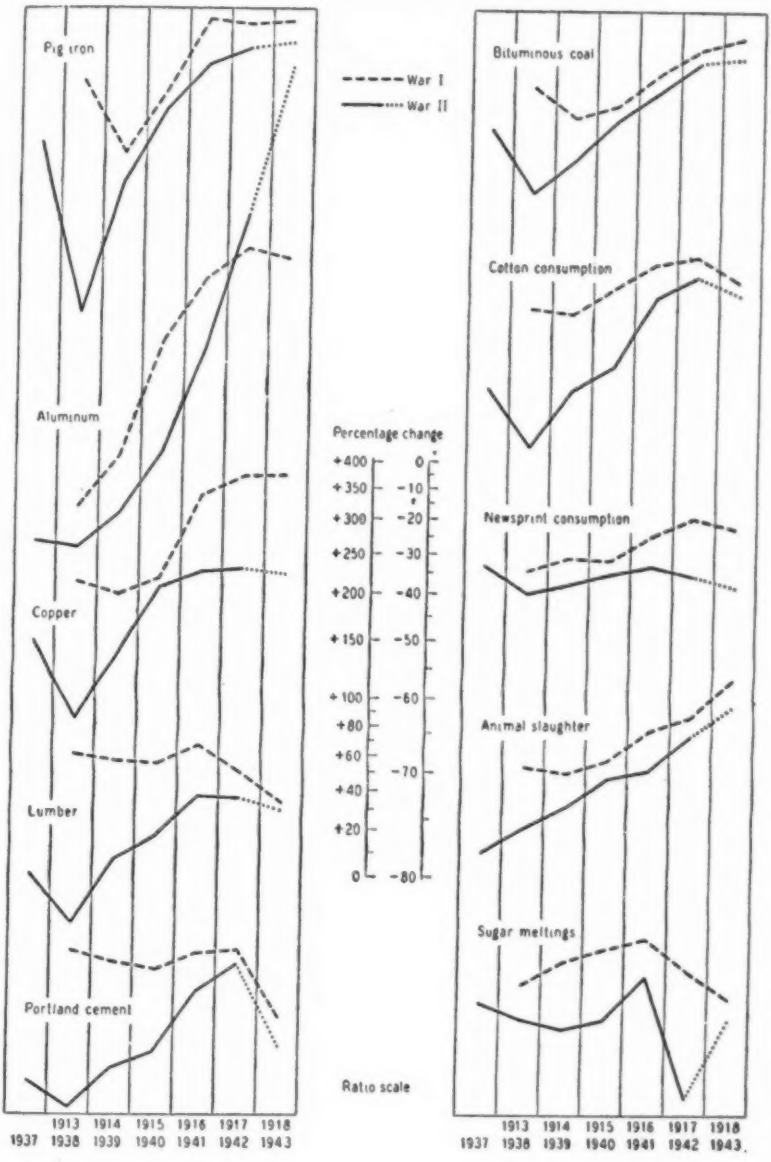
One other striking feature of the chart is the consistency of the changes from 1942 to 1943 with the general tendencies suggested by the movements in immediately prior years and in World War I. This chart was originally prepared by Arthur F. Burns and myself for use

[4] *Ibid.*, pp. 8–9, 32, 53–67.

[5] *Ibid.*, pp. 58–60. We have indeed taken a small step in the direction of revision, by adding rayon staple fiber to our index, substituting silk and nylon consumption for silk imports, and rubber consumption (crude, synthetic, and reclaimed) for crude rubber imports. The resulting index is (1937–43): 101, 83, 100, 112, 132, 136, 142. This revision does not have much to recommend it since it does not fully exploit the available data for World War II.

CHART II

Production of Basic Commodities, World Wars I and II



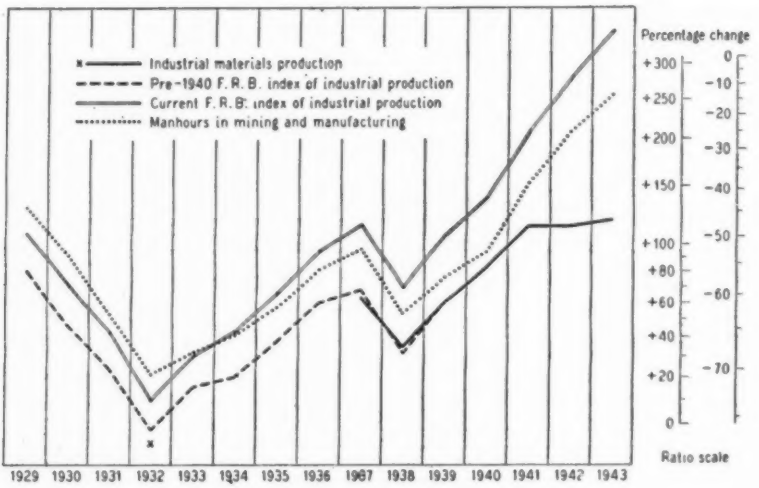
at a meeting in the fall of 1942, when only preliminary data for 1942 and no data for 1943 were available. In preparing it for publication now the 1942 data were revised and 1943 data added, as indicated by the dotted lines. While the 1943 figures were not, of course, actually forecast, it is gratifying to recall that considerable significance was attached to the similarity between the two periods and the then developing tendency towards a slackening rate of growth.

Do these comparisons of industrial materials production in the two wars suggest any conclusion with respect to total output in the two wars? The nature of the difficulty of measuring total output in wartime was indicated above. Some further evidence as to the difficulty is contained in Chart III. It will be observed that from 1929 to 1941 the

CHART III

Industrial Production and Employment

1929 – 1943



various production indexes move in rather close conformity with one another and with manhours in mining and manufacturing.[6] There is a difference in trend: the current Federal Reserve index rises relatively to

[6] Because of their similarity in coverage we have spliced the pre-1940 F.R.B. index (i.e. the index prior to its revision in August 1940) and the industrial materials index in 1939. The manhours index is based on B.L.S. estimates since 1939 ("Manhours in Agriculture, Mining, Manufacturing, and Construction, 1939–1943," mimeo. release LS 44–2729, Jan. 1944), and on a weighted average of Barger's index of manhours in mining and Fabricant's index of manhours in manufacturing prior to 1939 (H. Barger and S. H. Schurr, *The Mining Industries, 1899–1939: A Study of Output, Employment and Productivity*, National Bureau of Economic Research, 1944, p. 343; and S. Fabricant, *Employment in Manufacturing, 1899–1939*, National Bureau of Economic Research, 1942, p. 331).

the other production indexes, and the other production indexes rise relatively to manhours. But the difference in the trends of the production indexes, even when cumulated over the whole twelve-year period, 1929–41, is not nearly so large as the gap that develops in 1941–43 between the F.R.B. index and the materials production index; and the difference between the 1941–43 rates of increase in manhours and the materials index is almost as great, considering the prewar tendency for manhours to rise less rapidly than materials.

The following percentage changes relating to the war period summarize the situation:

	1939–41 Per cent	1941–43 Per cent
1. Current F.R.B. index of industrial production	49	47
2. Manhours in mining & manufacturing	43	41
3. Industrial materials production	34	2
4. Manhours per unit of materials, (2) ÷ (3)	7	37
5. Output per unit of materials, (1) ÷ (3)	11	44
6. Output per manhour, (1) ÷ (2)	4	4

It is clear that if the manhours and the materials indexes are valid there was a very considerable increase after 1941 in manhours per unit of materials. And if the Federal Reserve index is a valid index of total industrial production there was an equally remarkable increase in output per unit of materials after 1941, and a steady but moderate rise in output per manhour throughout the war period.

However, the computations underlying items 4, 5, and 6 above leave much to be desired in the way of comparability of coverage, statistical independence, and margin of error. The manhours index and the F.R.B. index are conceptually comparable, since both purport to cover mining and manufacturing. But neither is precisely comparable with the materials index, since the former does not include all the manhours used in fabricating materials, nor the latter all the output resulting from such fabrication. The principal omission is construction activity. If manhours in the construction industry were included in the manhours index the percentage change from 1939 to 1941 would be raised to 47 per cent, that from 1941 to 1943 lowered to about 32 per cent. The inclusion of the output of the construction industry in the F.R.B. index would presumably have similar effects.

It is clear that the manhours and the materials indexes are statistically independent computations. The F.R.B. and the materials index are not independent since most of the series in the materials index, or their close equivalents, are used in the F.R.B. index. This duplication

is, in part, inevitable, since materials output is necessarily a part of total output. But the duplication extends further, for by the system of "imputed weights" in the F.R.B. index many of the materials series are used to estimate the output of fabricated goods. The F.R.B. and the manhours indexes are not independent either, for the Board uses manhours figures to estimate production in a number of important industries.

I am not prepared to say what margin of error attaches to the manhours index. The possibilities of error in the materials index have been discussed elsewhere;[7] comparisons with other indexes covering similar areas of production, such as Ayres' grouping of F.R.B. materials series,[8] the materials index computed by the Board itself,[9] and the revision of our index described in note 5 above suggest that our index may understate the rise after 1941; but all these indexes show a much sharper decline in the rate of growth after 1941 than either the F.R.B. total index or manhours.

The error possibilities in the F.R.B. index have also been considered elsewhere.[10] It seems to me that the methods used to extend the coverage of the F.R.B. index, namely the use of imputed weights and the adjustment of manhours figures, are essentially arbitrary expedients and difficult to justify. An example of the use of imputed weights is afforded by the F.R.B. iron and steel index, which is based on three series: pig iron, with a weight (1935–39) of 1.70 per cent; open hearth steel, 8.70 per cent; and electric steel, 0.60 per cent. Part of the weight for open hearth steel (4.27 per cent) represents value added in the production of open hearth steel itself; the rest (4.43 per cent) represents value added in the rest of the "iron and steel industry," which concerns itself mainly with the fabrication of iron and steel products. In other words, the output of this part of the iron and steel industry is assumed to parallel the output of open hearth steel. To verify this assumption one would have to compute an index of output for this portion of the iron and steel industry and compare it with the open hearth steel series. Since there have been extensive changes in the kinds of products made by the industry during the war,[11] the validity of the assumption is not obvious, and it cannot be accepted even provisionally without specification as to how it has been, or could be tested.

[7] Occasional Paper 18, *op. cit.*, pp. 6–9, 53–67.

[8] Cf. *The Cleveland Trust Company Business Bulletin*, Feb. 15, 1944.

[9] This index, so far as I know, has not been published.

[10] Occasional Paper 18, *op. cit.*, pp. 40–52. See also Irving H. Siegel, "The Concept of Productive Activity," this JOURNAL, 39 (1944), pp. 227–228.

[11] Cf. Richard H. Lewis, "Conversion of Metalworking Industries to War Production, 1939–43," *Monthly Labor Review*, Dec. 1943, pp. 1086–87.

An example of the use of manhours series is afforded by the F.R.B. index of production for the automobile industry. The Board's method of computing this index, as the following figures indicate, is to multiply manhours by a productivity factor extrapolated on a straight-line

	Manhours	Productivity factor April 1939:100	Production
April 1939	100	100	100
April 1940	120	101	121
April 1941	149	102	152
April 1942	131	103	135
April 1943	207	104	215

basis. Again, the necessity for justifying this procedure, and the difficulty of doing it, is clear, when the changes in the character of the output of this industry are recalled. In April 1939 about 400,000 persons were employed in the making of automobiles, trucks and parts. In April 1943 the automobile industry employed[12] about 653,000, but only 110,000 were engaged in plants whose major product was automobiles, trucks or parts; the other 543,000 were distributed as follows: aircraft and parts, 277,000; tanks and parts, 101,000; bombs, guns, ammunition and other ordnance, 92,000; armored cars and scout cars, 27,000; other products, 46,000.

Disregarding the possible divergence between the production of open hearth steel and consumption of steel by the part of the iron and steel industry that it is taken to represent, it seems that the method used implicitly by the Board is to "count" products of this industry according to the amount of steel contained in them as and when they are produced. The result of such a "count" would be the total amount of steel consumed in the industry. Obviously this is not the only way to count the diverse products of this industry, nor does it conform with the basic principle of the index, which is to "count" unlike products according to the value added in their production in 1937. Similarly, disregarding the productivity factor for the automobile industry, which has a rather slight effect anyway, the method apparently is to "count" automobiles, aircraft, tanks, etc. according to the manhours required for their construction as and when produced. This, again, is not the same as value added (or even manhours) in 1937. The importance of the use of imputed weights and of adjusted manhours series in the F.R.B. index prevents one from saying much about the specific margin of error in that index; it does not prevent one from indicating a lack of confidence in the index.

[12] *Ibid.*, pp. 1086–87, 1092.

These observations on the character of the indexes in Chart III lead me to conclude:

(1) that a sharp spurt in manhours of industrial employment relative to materials used in production did actually take place after 1941;

(2) that the evidence is not sufficient to warrant the finding that there was a similar rise in total industrial output per unit of materials, or that total industrial output per manhour increased steadily during the war.

INTERPRETING THE STATISTICS OF MEDICAL EXAMINATIONS OF SELECTEES

By Edward A. Lew
Captain A.U.S.
Office of The Surgeon General, Army Service Forces

The fundamental policies governing the registration and selection of men for military service are laid down in the Selective Training and Service Act of 1940, as amended. This act provides that every person "inducted into the land or naval forces under this Act for training and service shall be given a physical examination at the beginning of such training and service . . . ." While the initial selection of sufficient men to meet the needs of the armed forces is a responsibility of the Selective Service System, the final decision as to the acceptability of any selectee from the physical standpoint rests with the Army (or the Navy). The physical standards for induction into the Army have been determined by the War Department, upon recommendation of The Surgeon General. Hence, one of The Surgeon General's major functions has been to review the physical examination reports.

Until shortly after Pearl Harbor, Selective Service registrants not deferred on account of dependents, occupation or for other reasons were given complete physical examinations by local board physicians, in accordance with the physical standards set up by The Surgeon General. The results of such examinations were recorded on a Selective Service form and tabulations from samples of these forms were made by the Selective Service System. Selectees deemed acceptable for general military service by the local boards were sent on to Army induction stations for a final type examination, which alone finally determined whether or not they would be inducted. The findings of this induction station examination were entered on an Army form.

Following the outbreak of the war, inductions were stepped up and it soon became impracticable to continue the dual system of examinations described above. Local boards were accordingly instructed to examine registrants with the objective of eliminating those with manifestly disqualifying defects, such as would be revealed by an inspection in the nude, by serological tests or from information available locally. Selectees passing such preliminary screening were forwarded to induction stations for the decisive and more comprehensive examination. The findings of this examination were entered on the same form which also recorded the report of the physical examination at the local board. This form—Report of Physical Examination and Induction—thus be-

came the official document for recording the results of physical examinations of Selective Service registrants by both local boards and induction stations.

Early in 1944 the system of physical examinations of selectees was changed again. Local board examinations were limited to registrants claiming manifestly disqualifying defects, and serological tests at the local board level were discontinued. While the character of the examinations at induction stations was left unchanged, they were given to practically all selectees as "pre-induction" examinations to determine acceptability for service in advance of induction. Selectees later called to active duty have at time of actual induction (at an Army reception center or Navy recruiting station) been subjected to a final physical check-up for contagious diseases and any inter-current illness or injury. Under this system the Report of Physical Examination and Induction has continued to be the official document for recording the results of the physical examinations at the local board, if any, at the induction station and at the Army reception center or Navy recruiting station.

In addition, induction stations have maintained records of their daily examination activities as a matter of administrative control, as well as for the purpose of furnishing information to higher authorities. To meet these latter needs a standard form of daily worksheet and standard forms of periodical reports have been developed. The form of report to the Office of The Surgeon General covering the results of the physical examinations of selectees is, in effect, a monthly tally sheet for the individual reports of examinations processed at an induction station. This summary report rendered by every induction station has set forth the number of examinations, inductions and rejections, with the rejections classified according to the principal disqualifying defect categories and with details also given separately for special groups of men examined or inducted. Similar reports have been rendered since February 1944 by every Army reception center, covering the results of the physical check-up at time of actual induction.

To make possible the computation of rejection rates at induction stations, the number of men inducted by (or acceptable on pre-induction examination to) the Navy has also been reported to The Surgeon General.

Samples of the individual physical examination reports in punch card form provide the most practicable means for studying details of examination findings. However, the overall results of the examinations, especially for particular induction stations, can be gauged more readily from summaries of examination results at induction stations.

This paper is limited to the problems encountered in the interpreta-

tion of statistics compiled from (1) individual reports of physical examinations of selectees, and from (2) summaries of the examination results prepared at induction stations. The former deal with the results of the examinations at both the local boards and the induction stations while the latter are concerned solely with the examinations at induction stations. The following discussion will for the most part be confined to the medical examinations of selectees at induction stations.

THE SELECTEES EXAMINED AT INDUCTION STATIONS

The individuals examined at an induction station must be regarded as a specially selected and highly variable sample of the male population at a particular time and place. The varying proportion of agricultural and war workers in the local population has had an important bearing on the type of man available for service. The composition of the group of selectees actually sent up for examination has been affected by prevailing Selective Service policies in regard to deferments for dependency, by the Armed Forces' policies in regard to the acceptance of special groups, by differential screening at the local boards, and by the extent to which men previously rejected were sent up again for examination. As a result, marked variations have been observed in the rejection rates at different induction stations at a particular time and at the same induction station at various times.

Changes in the type of selectee forwarded to induction stations can be associated in point of time with directives ordering review and reclassification of registrants previously deemed unavailable or unacceptable for military service. Thus the procedures laid down by Selective Service in July and August of 1943 for reclassifying registrants had the effect of increasing the proportion of previously rejected men sent up to induction stations in subsequent months. On the other hand, the calling up of fathers in significant numbers during the last quarter of 1943 is believed to have slowed down the rejection rate at induction stations, at least to the extent that fathers took the place of previously rejected men who might otherwise have been sent up for reexamination in greater numbers.

The effect of changes in the policies of the Armed Forces was especially notable in respect to volunteers, special groups and selectees with certain remediable defects. From December 1941 to November 1942, when the minimum age for service under the Selective Training and Service Act was twenty, the acceptance by the Armed Forces of volunteers at ages under twenty markedly affected the type of selectee age twenty sent up for induction. Since December 1942 a similar situation has existed for selectees aged eighteen, because of age seventeen

enlistments into the Navy, the Enlisted Reserve Corps and the Air Corps Enlisted Reserve. More spectacular in their effect on the overall picture of physical examination findings at induction stations were the limitations on the acceptance of illiterates, limited service men and other special groups. When such limitations were removed, there was a tendency toward "unloading" by local boards of the men who had previously been unacceptable. Likewise the decisions to accept men with certain remediable defects (such as tooth defects, visual defects and venereal diseases) temporarily increased the proportion of selectees with such conditions. This is illustrated by the situation which developed during the latter part of 1943 in regard to men with venereal diseases. Because of the special efforts made at that time to induct men once unacceptable on account of venereal infections, the proportion of Army inductees with venereal diseases during the last three months of the year was about double that for the year as a whole.

The nature of the screening at the local boards was first changed from a complete examination to an inspection type of examination during the first quarter of 1942. It was again changed early in 1944 by limiting local board examinations to men claiming disqualifying defects.

While the screening at local boards is relatively limited in scope, differences in this screening have nevertheless been an important factor affecting the interpretation of physical examination findings at induction stations. This was brought out in a study[1] of 4,994 men disqualified for general military service on account of cardiovascular defects, in which it was found that the proportion of men rejected for cardiovascular conditions at local boards was materially higher in New York, as compared with Boston. Differences in the screening effect of local examinations seem to reflect largely the differences in local board attitudes towards deferment, towards persons with borderline defects and towards sending back for reexamination men previously rejected at induction stations.

The most telling influence recently exercised by local boards on the type of man sent up to induction stations has proceeded from the reclassification and sending up for reexamination of men previously rejected. Except when changes in standards are involved, rejected men are again sent up for examination and induction only after the case has been reviewed by the local board's medical advisory board. The reconsidering of previously rejected men has naturally tended to be more intensive at those local boards which were hard pressed to meet their quotas. It appears that such reconsideration may have been more

[1] "Report of Reexamination of 4,994 Men Disqualified for General Military Service," *Journal of the American Medical Association*, Vol. 123, pp. 937–944 and 1029–35.

frequent for the milder psychiatric disorders than for other disqualifying defects.

The net result of these and other influences has been to confront induction stations with men whose characteristics have varied more widely than would generally be supposed.

THE NATURE OF THE INDUCTION STATION EXAMINATION

The findings of the examinations at induction stations are influenced by the objective of these examinations, by the examining procedures and by factors such as idiosyncrasies of the examining personnel and the attitude of the examinees.

The objective of the induction station examinations is to select men who are fit for the rigors of military service. However, Army regulations further provide that care should be taken not to accept men whom it may be necessary to discharge within a short time, and that the likelihood of subsequent claims on the government should be kept in mind by the examiners in considering the qualifications of registrants with questionable defects.

The standards of fitness for military service have been developed over a period of time as a matter of medical judgment and impressions gained in World War I. Such standards are of necessity subject to change since they have to be readjusted in relation to the Armed Forces' needs for men and the available supply of manpower. This is clearly demonstrated by the successive modifications made in U. S. Army peacetime standards with the progress of the war. The different standards used in Great Britain and the reported relaxation of standards in Germany also illustrate the fact that standards for military service can vary considerably under different circumstances. Quantitative experience data are unfortunately lacking regarding the relationship between findings upon examination and subsequent record of fitness, such as could serve as a check on the reasonableness of different standards.

It is important to keep in mind that the present Army standards take into consideration not only the really serious health impairments but also structural physical defects and mental conditions which can interfere with the performance of Army duties or otherwise render a man unfit for Army service. Such defects would not necessarily impair a man's health or prevent him from pursuing his civilian occupation. To a limited extent it has proved possible to utilize in the Army men who because of slight defects could not qualify for general military duties, but who could nevertheless be of value on special less physically exacting assignments.

Although Army regulations provide for the rejection of men who appear likely to become disabled in the near future, current fitness for general military service remains the fundamental criterion of the examinations. Consequently, the emphasis in the examinations has been on the detection of obvious defects which bear directly on acceptability for general military service. In respect of such defects the examinations have proved to be quite adequate.

In the case of borderline or doubtful findings, the Army regulations emphasize that the standards are simply a guide to the discretion of the examiners and that such standards should be construed, neither too strictly or arbitrarily, in the light of the objective of securing men who are physically fit. Since the great majority of defects are not measurable, considerable latitude must be allowed in the interpretation of borderline findings. This has operated to produce varying interpretations of standards in different localities. Recourse to the advice of consultants has sometimes also had the same effect, notably for defects in whose case precise diagnoses are difficult to make, for example certain psychiatric and cardiovascular defects. It should be borne in mind in this connection that most of the examiners at induction stations are civilian physicians, many of them specialists, imbued with an individualistic approach and not accustomed to following rules implicitly.

In respect of minor defects or conditions which do not bear directly on a selectee's acceptance for service, the examinations have not been very searching. The dominant factor in this regard has been the time element. Maximum attention has properly been focused, within the time available for the examination, on the detection of the principal causes of rejection. Since the examinations have not been made with the view of detecting all the minor defects, irrespective of their relevance to a man's acceptability for military service, they do not furnish a really satisfactory basis for determining the incidence of minor defects. In this respect, however, the examinations under pre-war physical standards will be found to provide much better information regarding minor defects than the examinations made since March 1942, when large scale inductions under standards adapted to war-time manpower needs began. Dental caries furnishes a good illustration. Following the lowering of the standards for teeth in February 1942, carious teeth ceased to be an important consideration in dental examinations and such examinations have since been frequently made with a tongue depresser only. As a result the reported incidence of dental caries among selectees has been of little value as an index of the actual condition.

Another limitation of the induction station examinations proceeds

from the examiners' reliance on the selectees for certain pertinent information. This has been especially important in getting medical histories, which provide the essential clues to the interpretation of many psychiatric, cardiovascular, and gastro-intestinal symptoms. Selectees anxious to be accepted into the armed forces have undoubtedly withheld unfavorable information, while those wishing to escape service have not infrequently exaggerated existing defects or simulated imaginary ones. The Armed Forces' experience with malingerers has not been one to constitute a serious problem, but the records of volunteers discharged for medical reasons have sometimes suggested the suppression of vital facts regarding medical histories.

The foregoing remarks are intended to stress the limitations on the use of physical examination findings of selectees for the purpose of appraising general health status or the incidence of minor defects. They also call attention to the bias sometimes introduced into the data by idiosyncrasies of the examining personnel and by the attitude of the examinees.

THE RECORDING AND REPORTING OF THE EXAMINATION RESULTS

The most serious difficulties originally encountered in the interpretation of the results of physical examinations can be traced to a lack of adequate instructions for recording and summarizing the examination findings. Successive improvements in instructions designed to effect uniform and consistent reporting and periodical checks on the observance of such instructions have generally proved sufficient to eliminate the worst disparities in reporting.

In tabulating the individual records of examination, the major problems were those of wide variations in terminology, indefinite terminology and differences in the interpretation of standards. These difficulties were in large part solved by the preparation of a special code for defects considered of importance for military service. This code was based on the conditions actually reported on individual reports of physical examinations, and was clearly preferable to adaptations of mortality or morbidity codes, since it related to the actual conditions affecting fitness for military service.

A more difficult problem was that of defining the defect responsible for the rejection in cases involving multiple disqualifying defects. For some time it was the practice to give psychiatric defects priority over physical defects, chiefly because of the great interest in psychiatric disorders. Recently a rule was promulgated that the most permanent and irremediable defect be listed as the principal defect responsible for rejection. No suggestions, however, were offered as to which defects

should be preferred in common combinations of disqualifying defects, many of which are related to one another.

Giving priority to psychiatric defects over physical defects had the effect of understanding the incidence of disqualifying physical defects among selectees. With this priority in effect, the higher the rejection rate for psychiatric defects the more did the reported rejection rate for physical defects understate the actual incidence of disqualifying physical defects. This was an important consideration in comparisons of rejection rates for physical defects between white and colored selectees, since the latter have been subject to much higher rejection rates for mental or educational deficiency.

In the case of summarized data reported monthly by induction stations to The Surgeon General, the most troublesome question has been that of allocating defects to the categories required to be reported. In the absence of specific directives there were considerable differences in practice from one induction station to another. Thus epilepsy was classified sometimes as mental and sometimes as neurological; poliomyelitis residuals were sometimes grouped with neurological defects and sometimes with musculo-skeletal. This unsatisfactory situation was eventually remedied by issuing a guide which lists a large number of defects, in regard to the allocation of which there might be some difference of opinion.

Differences in reporting practices are believed to be among the chief reasons responsible for the wide variation in rejection rates for individual defects from one area to another and especially from one induction station to another. Because of this, as well as the differences in the interpretation of standards and differences in local board screening, it has been very difficult to judge the extent of the geographical differences in the incidence of disqualifying defects.

INTERPRETATION OF THE RESULTS OF THE EXAMINATIONS OF THE SELECTEES

The results of the examinations of selectees have as a rule been presented in the form of rejection rates analyzed according to the principal defect categories responsible for rejections, and by race, by age, and by induction station (or broader areas, such as Service Commands). The typical problem has been to account for the changes in rejection rates by reference to changes in induction policies, procedures and standards, and by reference to the known locally specific differences in the characteristics of the men sent up for induction. This has involved constant attention to the changes being made in Selective Service and Armed Forces' policies, procedures and standards, insofar as they af-

fected the type of man sent up for induction, the type of man accepted and the examinations themselves.

Many of the changes in the trends of rejection rates could not be satisfactorily explained. Frequently the explanations lay in the technical features of the examination rules or the reporting. This has called for studied awareness of the peculiarities of the examinations and of the reports concerning them. In numerous instances, interpretation of the data has required primarily a statement of their limitations. This has been especially the case where there was some likelihood of the data being used for purposes for which they were not intended or for comparison with other series.

Thus, it has appeared advisable to stress that rejection rates had been computed on the basis of the number of examinations and not the number of individuals. To the extent that many selectees had been examined and rejected more than once, the rejection rates based on examinations have of course overstated the rejection rates which would have been obtained from an unduplicated count of the individuals examined. In other words, rejection rates computed on the basis of examinations have exaggerated the incidence of disqualifying defects, especially for those defects for which previously rejected men were prone to be sent up for reexamination.

Likewise, it has seemed wise to point out repeatedly that the high rejection rates reported during the prewar period of Selective Service did not imply a low level of national health. The then effective standards for military service were in many respects different from the standards of health compatible with efficient performance in civilian life, so that men failing to meet them could not necessarily be regarded as sick or disabled.

The question has often been raised as to what the findings of the medical examinations would have been, if a particular group of selectees had been more representative of some larger population. In those cases where it was possible to appraise the more important selective influences in quantitative terms, their effect could readily be allowed for. Not infrequently, however, the effect of such influences could at best only be estimated from general knowledge of the situation as falling within a wide range. This proved to be no less true in the case of relatively large groups of selectees, such as those examined in broad sections of the country over a long period of time, than when dealing with selectees examined at a particular induction station during a single month.

Misunderstanding has sometimes been occasioned by comparisons of rejection rates with other only partially parallel series. To avoid

such misunderstandings, the major points of difference have been stressed even in comparisons with reasonably similar series. Thus in comparing medical rejection rates for WAAC candidates with corresponding rates for selectees, the fact that the applicants for enrollment in the WAAC were volunteers was carefully emphasized. As volunteers the WAAC candidates were subjected to considerable screening before being medically examined, whereas the selectees examined at induction stations had not been subjected to any comparable screening and furthermore included a sizeable proportion of previously rejected men.

Questions have also arisen in regard to the relationship between rejection rates and discharge rates for individual induction stations or wider areas. Such comparisons were first made because of the feeling that the adequacy of the examinations at induction stations could be judged by the proportion of inductees discharged within a short time after induction. This tentative conclusion was based on the theory that induction stations with high rejection rates were selecting men for the Army so efficiently that the subsequent discharge rates would be small. Conversely, induction stations which showed low rates of rejection would be expected to have higher rates of discharge. This reasoning assumed that induction station examinations were pointed at and could be highly effective in eliminating potential discharges and that differences in the type of man sent up for induction between one induction station (or area) and another could be disregarded, so that the rejection rates could be expected to reflect chiefly the differences in the screening at various induction stations.

It is not surprising that lack of correlation between rejection rates and discharge rates was therefore sometimes misconstrued as being indicative of inadequate examinations at some induction stations. Actually, a number of combinations of circumstances could have accounted for lack of correlation.

For instance, if the ability of all induction stations to detect potential discharges traceable to a man's condition at time of induction was of a uniformly low order, correlation between rejection rates and discharge rates could not be expected. Since it now appears that induction station examinations are not markedly selective of potential discharges for at least certain types of defects (e.g. certain psychiatric disorders) lack of correlation between rejection rates and discharge rates for such defects is not surprising. In this connection it should be recalled that induction station examinations were designed to determine current fitness rather than to detect potential discharges. No definitive studies moreover have been made of the effect of particular defects on the discharge rate, analogous to those carried out by life insurance companies to

determine the effect of particular medical impairments on mortality.

If the ability to detect potential discharges traceable to a man's condition at time of induction varied markedly from one induction station to another, some inverse correlation between rejection rates and discharges might, a priori, be expected. However, available evidence suggests that this could be completely masked by the differences between induction stations in respect of the type of selectee sent up for induction.

Finally it is necessary to keep in mind that the induction station examination cannot influence the discharges which result from the fortuitous incidents of military service nor from other conditions which develop after induction. If the ratio of discharges traceable to the physical state of selectees at time of induction to total discharges were relatively small, such correlation as existed between rejections and discharges due to the physical state of selectees at time of induction might, nevertheless, not be perceptible in comparisons between rejection rates and total rates of discharge.

Thus, only in the case of induction stations with reasonably similar types of selectees, but with varying ability to detect potential discharges could any inverse correlation be expected between rejection rates and discharge rates, and this correlation would be perceptible only if discharges originating from conditions existing at time of induction constituted a sizeable proportion of all discharges.

APPLICATIONS OF THE STATISTICS OF MEDICAL EXAMINATIONS OF SELECTEES

The statistics of medical examinations of selectees have proven of great value to the Army for administrative purposes and in furnishing information regarding the physical characteristics of the men inducted and rejected.

The individual reports of physical examinations have made it possible to determine rejection rates for particular physical and mental defects in considerable detail. They have also been the only source of information regarding rejections by age, a matter of great importance in shaping policies for the most effective use of manpower. Knowledge of rejection rates for individual defects, by age, race and for broad subdivisions of the country has been extremely pertinent in revisions of physical standards. In this connection, estimates were frequently made of the number of men rejected for certain defects, who would become available to the armed forces if standards for the particular defects, were modified. This has involved translating the rejection rates based on the number of examinations into rates reflecting the numbers

of individuals rejected and also studies of the association between disqualifying defects, in order to make allowance for the number of men with a particular disqualifying defect who also had other disqualifying defects.

The summary reports of medical examinations at induction stations have furnished the absolute numbers of examinations and rejections (by cause) for each induction station. This information while somewhat limited in scope has greatly facilitated comparative reviews of examination results at different induction stations. The summary reports have also served as controls on the examination practices of induction stations. As such they were instrumental in obtaining more uniform adherence to standards and in the improvement of procedures. The reports have also supplied current data regarding special groups, for instance limited service men, illiterates and inductees with venereal diseases.

Certain details of the physical characteristics of Army inductees, notably their height and weight distributions, have been very much in demand, and were readily obtained from sample tabulations of the individual physical examination reports. Dental findings, especially for non-restorable teeth, have been used to estimate the dental work required to be done for inductees. Findings on visual acuity have also been used for similar purposes. Most of the requests for information regarding physical characteristics of the Army have related to specific practical problems and little has been done so far to obtain a general physical picture of the men in the Army.

The desirability of developing quantitative judgments regarding the prognostic significance of physical characteristics suggests that follow up studies be made for samples of inductees with certain characteristics at time of induction. Such investigations could trace the amount of time lost from duty on account of sickness or disability and the number of discharges for each group, relating the days lost or the discharges to the average experience of the Army. In this manner numerical measures could be obtained of the extent to which the experience of inductees with certain physical characteristics departed from the average for the Army as a whole. Such indices should prove helpful not only in the consideration of standards of fitness for service, but also in shedding light on the effect of physical and mental defects on morbidity and the occurrence of disabilities.

APPLICATION OF THE LOGISTIC FUNCTION TO BIO-ASSAY

By Joseph Berkson, M.D.

*Section on Biometry and Medical Statistics, Mayo Clinic, Rochester, Minnesota**

Following the observation that under certain circumstances, if the dosage of a drug is expressed in proportion to its logarithm, the effect, measured as the percentage of individuals killed (or other all-or-none effect) in relation to the dosage, assumes the form of a more or less symmetric sigmoidal curve, the integral of the normal curve has been employed for the estimation of the potency of a drug [5]. Bliss has applied and advanced this method extensively.

I have utilized for the same purpose another function given by equation (1) and shown in Chart I, owing to my familiarity with its application to other experimental problems [12]. The laboratory of Professor E. B. Wilson also has used this function for this purpose [14]. The function (1) has been variously called the "growth function," the "autocatalytic curve" and by other terms, according to the application to which it was put. It was rediscovered for the description of population growth by Pearl and Reed [11] who, following Verhulst, called it the "logistic" function. Since its wide statistical use stems, I feel confident, from the extensive applications made by Pearl and Reed, I shall refer to it by the general term "logistic."

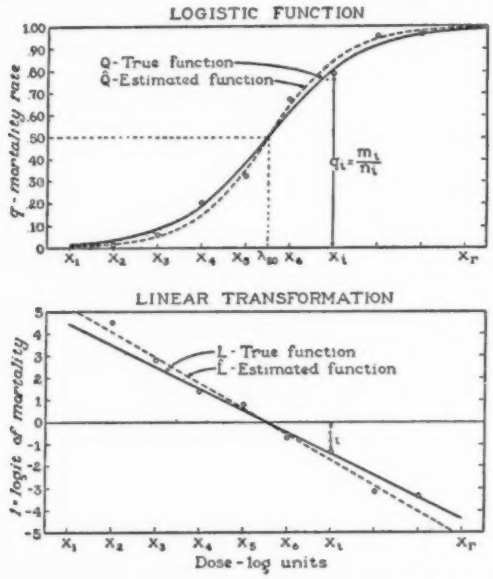
The use of the integral of the normal curve to give the proportion of individuals affected at a given dosage follows nicely from the hypothesis that the susceptibility among individuals is distributed according to the normal curve. If the minimal lethal dose measures susceptibility and if susceptibility is distributed normally among individuals, it follows that the proportion of individuals in a population exposed to a dosage x which will be killed will be the integral up to x of the normal curve of distribution of susceptibility. In view of the wide use of the normal curve to represent the distribution of biologic traits and also because of direct experimental evidence of the normal distribution of susceptibility [4], it is to be conceded that the integral of the normal curve recommends itself.

However, the logistic function is very close to the integrated normal curve [17], it applies to a wide range of physicochemical phenomena [12] and therefore may have a better theoretic basis than the integrated normal curve. Moreover there are reasons for believing it to be easier

* On leave, Col., Medical Corps, Army of the United States, Chief, Statistics Division, Office of the Air Surgeon.

CHART I

THE LOGISTIC FUNCTION AND ITS LINEAR TRANSFORMATION


LOGISTIC FUNCTION
Q - True function
Q̂ - Estimated function
Q - mortality rate
$Q_i = \frac{m_i}{n_i}$
x_1 x_2 x_3 x_4 x_5 λ_{50} x_6 x_i x_r
LINEAR TRANSFORMATION
L - True function
L̂ - Estimated function
l - logit of mortality
Dose - log units

The following are definitions of the quantities shown in Chart I or used elsewhere in the paper and equations used in the paper:

Q = "True" logistic function of mortality rate versus x corresponding to parameters α and β

$P = 1 - Q$

$\widehat{Q}$ = fitted function corresponding to a and b, estimates of the parameters

$\widehat{P} = 1 - \widehat{Q}$

x_i = dose in log. units

q_i = observed mortality rate for dose $x_i = \frac{m_i}{n_i}$

$p_i = 1 - q_i$

m_i = number of dead at x_i

n_i = number exposed at x_i

$\lambda 50$ = log L.D. 50, the dose for which the mortality rate is 50 per cent $= \alpha/\beta$

l = logit $= \ln \frac{(1-q_i)}{q_i} = \ln \frac{p_i}{q_i}$

L = logistic function in terms of logits corresponding to Q

$\widehat{L}$ = logistic function in terms of logits corresponding to $\widehat{Q}$

$$Q = \frac{1}{1+e^{\alpha-\beta x}} \tag{1}$$

$$\widehat{Q} = \frac{1}{1+e^{a-bx}} \tag{2}$$

$$\ln\left(\frac{1-Q}{\widehat{Q}}\right) = \widehat{L} = a - bx \tag{2.1}$$

$$\frac{\partial \widehat{Q}}{\partial a} = -(\widehat{Q})\,(1-\widehat{Q}) = -\widehat{Q}\widehat{P} \tag{3}$$

$$\frac{\partial \widehat{Q}}{\partial b} = x(\widehat{Q})\,(1-\widehat{Q}) = x\widehat{Q}\widehat{P} \tag{4}$$

to handle statistically. I, therefore, thought it would be worth while to examine both forms comparatively.

For the purpose, there were collected as many examples as I could find of dosage mortality data in which the observations were sufficiently numerous and for which the integrated normal curve had been used already. The logistic function was applied to the same data and the results were compared. For the normal curve, evaluations by the method of maximum likelihood formulated by Bliss and Fisher [1] were utilized as given by the authors of the examples used when they were available, and when they were not, by obtaining a solution following the same method.

For the application of the logistic function, the question arose as to what method of fitting to utilize, and in particular whether to attempt to fit by the method of maximum likelihood. The principle of this method has been employed by many workers in particular situations, but under the name of maximum likelihood it has been advocated for general application by Professor R. A. Fisher. The method seems to be favored also by other mathematical authorities including, at least for the present application, Professor E. B. Wilson [12].

In spite of earnest prayer and the greatest desire to adhere to proper statistical behavior, I have not been able to see why the method of maximum likelihood is to be preferred over other methods, particularly the method of least squares. In the logistic function (1) there are two parameters α and β which if known determine the effect at any dose. The L. D. 50, that is, the dose which is lethal to just 50 per cent of the population exposed, is given by α/β. The principle of maximum likelihood is to choose such values a and b as estimates of α and β as would, if they were actually the parameters α and β, give the observations in hand with greater probability than any other values. That is, if values a_1, b_1, for α, β give the observations in hand with greater probability than values a_2, b_2, the values a_1 b_1 are said to have greater likelihood than a_2, b_2, and the values which give the observations with greatest probability are those of maximum likelihood. The maximum likelihood values are determined by obtaining the expression for the probability of all the observations occurring together, or its logarithm, differentiating with respect to the parameters and solving for maximum values. The method has considerable immediate plausibility. It employs a principle used in inverse probability and it has a generality which is attractive. However, the results that it gives in some cases conflict with other principles that seem equally well or better established. It is known that in some instances the method yields biased estimates of the parameters, that is, the expected value of the estimate does not equal, but is greater or less than the true value. If the method of maximum

likelihood and that of least squares give different results in the case of fitting a curve, it is an open question whether the χ^2 distribution applies to deviations from the maximum likelihood solution or from that given by least squares, and I suspect strongly that the standard errors of the estimated parameters will be larger for the method of maximum likelihood.

If the mortality rate at x_i is $Q_i(P_i=1-Q_i)$ the probability of an observation $q_i=m_i/n_i$, that is, m_i deaths out of n_i exposed, is given by

$$P\{q_i \mid x_i\} = \frac{n_i!}{n_i!(n_i - m_i)!} Q_i^{m_i} P_i^{n_i - m_i} = C_i Q_i^{m_i} P_i^{(n_i - m_i)}. \tag{5}$$

The probability of all the q's taken together is given by the product of (5) for all the q's. L, its natural logarithm[1] with Q taken from the estimated logistic function (2), is the sum of the logarithms and is given by

$$L = \sum \ln C_i + \sum m_i \ln \widehat{Q}_i + \sum (n_i - m_i) \ln \widehat{P}_i. \tag{6}$$

The derivatives of L with respect to a and b, which are to be equated to zero for maximum likelihood with appropriate substitutions from (3) and (4), are

$$\frac{\partial L}{\partial a} = \sum \frac{\partial \widehat{Q}}{\partial a}\left(\frac{m_i - n_i\widehat{Q}_i}{\widehat{Q}_i\widehat{P}_i}\right) = -\sum (m_i - n_i\widehat{Q}_i)$$
$$= -\sum n_i(q_i - \widehat{Q}_i) = 0 \tag{7}$$

$$\frac{\partial L}{\partial b} = \sum \frac{\partial \widehat{Q}}{\partial b}\left(\frac{m_i - n_i\widehat{Q}_i}{\widehat{Q}_i\widehat{P}_i}\right) = \sum x_i(m_i - n_i\widehat{Q}_i)$$
$$= \sum (n_i)(x_i)(q_i - \widehat{Q}_i) = 0. \tag{8}$$

From (7) and (8) the conditions for maximum likelihood are

$$\sum n_i\widehat{Q}_i = \sum n_i q_i \tag{9}$$

$$\sum n_i x_i\widehat{Q}_i = \sum n_i x_i q_i. \tag{10}$$

According to the principle of least squares the sum of the weighted squared differences $\sum W_i(q_i-\widehat{Q}_i)^2$ is to be minimized, with the weight W_i taken as inversely proportional to the variance of the observation q_i. The variance of q_i is P_iQ_i/n_i. For this condition of least squares a solution cannot be given directly in terms of the logistic in form (1), for the primary reason that the function in this form is not linear in the parameters to be evaluated, and also because the weights con-

[1] L used in (6), (7) and (8) has a different connotation than when used elsewhere in this article.

tain the unknown quantities PQ. It can be expanded in terms of a Taylor series and a least squares solution obtained as closely as desired by successive approximation. This method is classic and numerical examples are given by Schultz [13] and by Pearl [10]. It is a rather arduous procedure, however. If instead of the observations q_i we deal with their logits[2] $l_i = ln(p_i/q_i)$ then for not too large differences, $(q_i - \widehat{Q}_i)^2$ is given with close approximation by

$$(q_i - \widehat{Q}_i)^2 \rightleftharpoons (\widehat{P}_i\widehat{Q}_i)^2(l_i - \widehat{L}_i)^2 \tag{11}$$

or better still by

$$(q_i - \widehat{Q}_i)^2 \rightleftharpoons (\widehat{P}_i\widehat{Q}_i)(p_iq_i)(l_i - \widehat{L}_i)^2. \tag{11.1}$$

If now, since we do not know the "true" values PQ we define the least square weights in terms of the fitted function we have from (11.1)

$$\chi^2 = \sum \frac{n_i}{\widehat{P}_i\widehat{Q}_i}(q_i - \widehat{Q}_i)^2 \rightleftharpoons \sum n_i(p_iq_i)(l_i - \widehat{L}_i)^2. \tag{12}$$

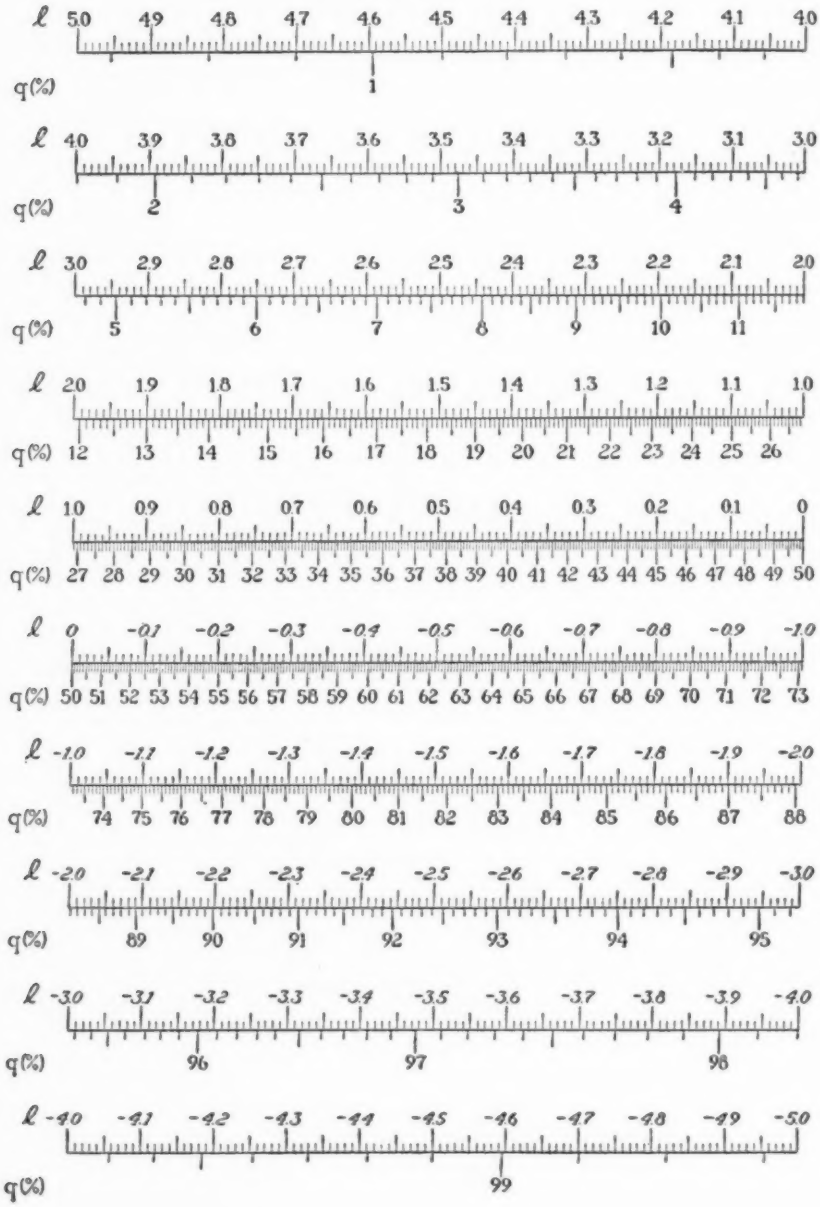
It is the quantity on the left of (12) which according to the principle of least squares is to be minimized. The fact is notable that by use of the approximation (11.1) which is a good one, the weights on the right side of (12) are formulated entirely in terms of the observed quantities n and pq, that is the weights do not contain the fitted values $\widehat{P}\widehat{Q}$. This simplification is exceptional with the logistic for fitting a function to a series of observed rates by least squares; for instance, this sort of reduction does not result from a similar treatment of the exponential or the integrated normal curve. A consequence of (12) is that a least square solution can be obtained directly without successive approximation in spite of the fact that the function (1) is not linear in the parameters, the degree of exactness being limited only by the approximation (11.1). Since $\widehat{L} = a + bx$ the problem is reduced to that of obtaining a least square solution of a linear function with weight $W_i = n_ip_iq_i$ for l_i instead of the more usual n_i. The method of solution then is as follows.

For each observation q_i at x_i the logit $l_i = ln(1 - q_i/q_i)$ is evaluated. Chart II gives the logits corresponding to different values of q conveniently and with sufficient accuracy for most purposes. A least square solution for the function in linear form for logits (2.1) is obtained weighting each observation with the weight $W_i = n_ip_iq_i$. This will be a close approximation of a least square solution in terms of the

[2] I use this term for ln p/q following Bliss, who called the analogous function which is linear on x for the normal curve "probit."

CHART II

NOMOGRAPH FOR OBTAINING THE LOGIT (l) CORRESPONDING TO A GIVEN MORTALITY RATE (q) AND VICE VERSA



logistic (2). An example of the arithmetic procedure is given in Table I. In some instances the observed mortality was zero or 100 per cent. For such an observation the logit cannot be utilized since it becomes infinite at these values. In that case a preliminary solution can be obtained omitting the observation in question and a substitute observation used, half way between the estimate given by this fit and the actual observation.[3]

TABLE I

CALCULATION OF LOGISTIC FUNCTION

Concentration	Number exposed	Mortality rate	Log concentration	Logit	Weight $=npq$		Expected logit	Expected mortality		$\text{Chi}^2=\frac{n(q-\hat{Q})^2}{\hat{P}\hat{Q}}$
	n	q	x	l	w	wx	$\hat{L}$	$\hat{Q}$	$\hat{P}\hat{Q}$	χ^2
40	462	.2359	1.6021	1.175	83.28	133.4229	1.262	.2206	.171936	0.629
60	500	.3980	1.7782	0.414	119.80	213.0284	0.266	.4339	.245631	2.623
80	467	.6380	1.9031	−0.549	108.39	206.2770	−0.441	.6085	.238228	1.255
100	515	.7184	2.0000	−0.937	104.19	208.3800	−0.990	.7291	.197513	0.299
120	561	.8182	2.0792	−1.504	83.45	173.5092	−1.438	.8081	.155074	0.369
140	469	.8529	2.1461	−1.758	58.84	126.2765	−1.816	.8601	.120328	0.202
160	550	.9000	2.2041	−2.197	49.50	109.1030	−2.145	.8952	.093817	0.135
180	542	.9207	2.2553	−2.452	39.57	89.2422	−2.435	.9195	.074020	0.011
200	479	.9395	2.3010	−2.743	27.23	62.6562	−2.693	.9366	.059380	0.068
250	497	.9577	2.3979	−3.120	20.13	48.2697	−3.242	.9624	.036186	0.303
300	453	.9757	2.4771	−3.693	10.74	26.6041	−3.690	.9756	.023805	0.000

$$\Sigma w = 705.12$$
$$\Sigma wx = 1396.7692$$
$$\bar{x} = 1.98090$$
$$\Sigma wl = -621.56791$$
$$\bar{l} = -0.881507$$
$$\Sigma wx^2 = 2801.21271$$
$$\frac{(\Sigma wx)^2}{\Sigma w} = -2766.85415$$
$$34.35856$$
$$\Sigma wxl = -1425.72192$$
$$\frac{\Sigma wx \Sigma wl}{\Sigma w} = -1231.26120$$
$$-194.46072$$

$$b = \frac{-194.46072}{34.35856} = -5.659746$$

$$a = \bar{l} - b\bar{x} = 10.329884$$

$$\hat{L} = 10.329884 - 5.659746x$$

$$\text{Log L.D. } 50 = \frac{a}{b} = 1.82515$$

$$\text{L.D. } 50 = 66.9$$

$$\chi^2 = 5.89$$

[3] A procedure of successive approximation which may be utilized is the following. Obtain a preliminary solution by fitting graphically to the logits, yielding first estimates $\hat{L}_i$, $\hat{P}_i\hat{Q}_i$ for each x_i. Substitute for each observed value of the logit l_i a value $l_i' = \hat{L}_i - (q_i - \hat{Q}_i/\hat{P}_i\hat{Q}_i)$ to fulfill equation (11). Make the least square solution for the substituted instead of the observed logits, using weights $n_i\hat{P}_i\hat{Q}_i$, the values $\hat{P}_i\hat{Q}_i$ being given by the first approximation. The rule of substituting a value l' for l to fulfill equation (11) furnishes another method for obtaining a value to use when the observed q is zero or 100 per cent. For zero per cent the substitute value becomes $l' = \hat{L} + (1/\hat{P}_i)$ and for 100 per cent $l' = \hat{L}_i - (1/\hat{Q}_i)$. The method outlined in this footnote is essentially that followed by Bliss and Fisher for fitting the integrated normal curve. It can be derived by applying the approximation (11) to the conditions for a maximum likelihood solution given in (7) and (8). Applied to the logistic it is considerably more complicated than the method given in the text. Moreover it yields a higher χ^2 generally.

The comparison between the logistic and the normal curve for the examples found is given in Table II. It is seen that on the basis of the comparative χ^2 values either the results are practically the same, or there is an advantage in favor of the logistic. In no instance did the normal curve appear the better of the two. The one case in which the advantage of the logistic is appreciable, namely that of the Murray [9] male fly series, is that in which the observations were most numerous.

TABLE II

COMPARISON OF THE LOGISTIC AND THE NORMAL CURVE IN THE ESTIMATION OF DRUG POTENCY

Series	Number of dosages	Total observations	Logistic		L.D. 50		Sum of weighted squared deviation χ^2	
			a	b	Logistic	Normal	Logistic	Normal
Woodard and others [18]	8	80	5.9842	8.0459	5.54	5.52	2.77	3.01
Chen and others [2]	8	80	−15.8464	15.3321	0.0926	0.0913	7.77	8.04
Bliss, series I [1]	6	175	70.9035	39.8781	60.0	60.1	1.09	1.12
Bliss, series II [1]	6	187	74.4771	41.8241	60.4	60.1	4.85	5.03
Garwood [6]	5	200	11.0581	3.8767	0.00140	0.00142	1.75	2.69
Murry, Table I, female flies [9]	7	3,121	17.0358	7.2980	215.9	215.8	2.39	3.38
Murray, Table I, male flies [9]	11	5,495	10.3299	5.6597	66.9	66.6	5.89	11.45

It is possible that with a sufficiently large number of observations the logistic would appear generally to give the better fit. It is not to be expected that the difference will be great, since both curves are much alike. I believe that the work of fitting the logistic as given here is considerably simpler than that of fitting the normal curve by probits and maximum likelihood as advocated by Bliss and Fisher.

REFERENCES

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THE RELATIVE EFFICIENCIES OF GROUPS OF FARMS AS SAMPLING UNITS*

By Walter A. Hendricks

Bureau of Agricultural Economics, U. S. Department of Agriculture, Raleigh, North Carolina

Sampling units consisting of groups of farms are useful as a device for reducing travel costs in enumerative surveys. When such sampling units are employed, it is helpful to have some advance information regarding the loss of precision introduced by grouping. If neighboring farms are more nearly alike than farms in different locations, obviously the loss will be large. Such information can often be obtained from an analysis of data previously collected. When groups of a specified size have once been used it is possible to predict, at least approximately, the results that would have been obtained from groups of a different size.

When the grouping is such that it represents a problem in subsampling, the analysis involves no difficulties. For example, an area to be covered by a survey can be divided into N units with K farms per unit. The sample might consist of n units drawn at random with k farms selected at random from each unit for enumeration. From an analysis of variance giving the mean squares between units and within units it is possible to estimate the variance of the true unit averages, V_g, and the variance of individual farms within units, V. The variance of the mean for a sample of n units with k farms enumerated per unit is given by the equation,

$$V_{\bar{x}} = V_g(1/n - 1/N) + V(1/nk - 1/NK). \qquad (1)$$

The values of V_g and V estimated from the analysis of variance can be accepted as constant for any values of n and k. The variance of $\bar{x}$ for a sample consisting of any assigned number of units, with any assigned number of farms enumerated in each unit, can thus be predicted without difficulty. Equation (1) may be modified to fit cases where k and K are not constant from one unit to another without introducing any theoretical complications.

It should be noted that this kind of grouping is not exactly equivalent to using groups of neighboring farms as sampling units; the k farms selected from a unit are taken at random from among the K that are

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present. However, in some respects the two methods of sampling are similar. Suppose that n groups, each consisting of k neighboring farms, have been used as sampling units in a survey. If there are Nk farms in the universe sampled, the universe may be regarded as made up of N groups of k neighboring farms. An analysis of variance of the data will yield an estimate of the variance of the true group averages, V_g, and an estimate of the variance of individual farms within a group, V, as in the subsampling scheme. The variance of a mean based on a sample of n such groups can be estimated from equation (1) which in this case can be simplified to the form,

$$V_{\bar{x}} = (V_g + V/k)(1/n - 1/N). \tag{2}$$

The values of V_g and V can be regarded as constants for any values of n as in the subsampling scheme. But if k is given a value other than the one actually used in the original analysis of variance, a theoretical difficulty arises. As the groups are made larger it is reasonable to expect that the value of V should also increase. The upper limit to the value of V is reached when k is equal to the total number of farms in the universe. V will then be equal to the total mean square for the finite universe sampled. The increase in the value of V must be accompanied by a decrease in the value of V_g because the total mean square in the finite universe must remain constant. So long as the values of k substituted in equation (2) do not differ too widely from the one used in the original analysis of variance, it is not likely that any serious error will be introduced by assuming that V_g and V are constant for different values of k. The relative efficiency of a sampling unit of k neighboring farms as compared with an individual-farm sampling unit is probably given fairly accurately by the equation,

$$I = \frac{V_g + V}{kV_g + V} \tag{3}$$

where V_g and V are assumed constant for all values of k.

The extent to which this approximation is justified is of considerable theoretical and practical interest. The degree of change in the values of V_g and V as k increases or decreases obviously depends upon the way the farm character under investigation varies from one locality to another. Any general law that may be invoked to describe those changes can only reflect what happens "on the average." This raises the question as to whether a general law which satisfies even these mild specifications can be found. A possible solution is suggested by the results of experimental work in agronomy.

The variability of crop yields from unit to unit on experimental plots has been studied extensively for units of different sizes. When a large unit is considered as though it were made up of several smaller neighboring units, the problem of estimating variability between units for units of different sizes on an experimental plot is identical with the one under discussion here. A thorough study of this problem by H. Fairfield Smith[1] shows that the variance of the average yield per unit for individual blocks of k neighboring units in a field is given by the equation,

$$V_k = \frac{V}{k^a} \tag{4}$$

or

$$\log V_k = \log V - a \log k. \tag{5}$$

In these equations V represents the total mean square of all units in the field rather than the mean square of units within blocks. V_k represents the variance of the group averages rather than the variance of the mean for the entire sample as in equation (1). Although derived by empirical methods, the equations appear to fit agronomic data fairly well. Data on peanut yields at North Carolina State College, which were made available to the author by the Agronomy Department, will serve for illustrative purposes.

Yields were recorded for 16 separate row segments 12.5 feet long on each of 36 rows in an experimental plot. These segments were combined to form larger units by averaging the yields from segments directly across from each other on adjacent rows. This provided 16 sets of data for each of which it was possible to measure the variance of the mean yield per segment between groups of different sizes. The 36 rows provided 2 groups of 18 segments, 3 groups of 12, 4 groups of 9, 6 groups of 6, 9 groups of 4, 12 groups of 3, and 18 groups of 2. The average variance of the group means for the 16 sets of data, expressed on a per segment basis, were computed. The relation between the variance of the group means and the size of the group is shown in Chart I. Equation (5), fitted to the data, yielded the straight regression line shown on the chart. For these data $a = 0.52720$. If there were no correlation between segments in a group, a would have been equal to unity. These results are typical of the effect of soil heterogeneity on the variability of group averages. The variances of the group means are somewhat erratic when the groups are small, but on the whole the relationship is fairly good.

[1] Smith, H. Fairfield, "An empirical Law Describing Heterogeneity in the Yields of Agricultural Crops," *Journal of Agricultural Science* 28 (1): 1–23. 1938.

It seems reasonable to expect the variability of farm data to obey a similar law when neighboring farms are grouped into larger sampling units. Unfortunately farm data to test the relationship are not so plentiful as data from field-crop experiments, but some indication of the behavior of farm data can be obtained from results recently pub-

Chart I

Relation between variance of average peanut yield per row segment ($V_{\bar{x}}$) and number of segments per group (k) - - N. C. Agricultural Experiment Station Data.

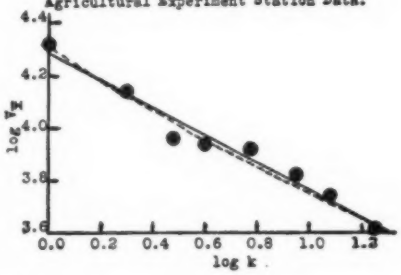
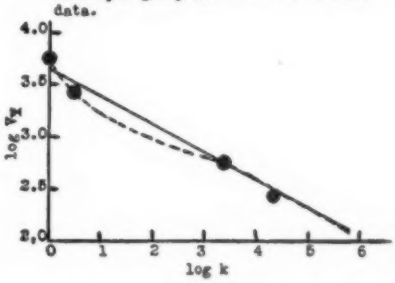


Chart II

Relation between variance of average cropland per farm ($V_{\bar{x}}$) and number of farms per group (k) - - N. C. farm data.



lished by Finkner, Morgan, and Monroe.[2] An enumeration of 4,214 farms in North Carolina, in which groups of 3 neighboring farms were used as sampling units, yielded the analysis of variance of cropland per form shown in Table I.

TABLE I

ANALYSIS OF VARIANCE OF CROPLAND FOR 217,976 FARMS IN NORTH CAROLINA

Source of variability	Degrees of freedom	Mean square
Between crop reporting districts	7	8,161,056
Between counties within districts	92	663,967
Between 3-farm units within counties	72,749	6,350
Between farms within units	145,127	4,619
Total	217,975	5,737

From this table, which is the analysis of variance of the sample inflated to a State basis, it is possible to estimate the variance of the means of groups of several sizes within the State. The total mean square is an estimate of the variance of the individual farm data for the State as a whole. Considering all farms in a crop-reporting district as a group, an estimate of the variance of the means for groups of that

[2] Finkner, A. L., Morgan, J. J., and Monroe, R. J. "Methods of Estimating Farm Employment from Sample Data in North Carolina. *N. C. Agr. Expt. Sta. Tech. Bul. 75*, 35 pp. 1943.

size is given by dividing the mean square between districts by the appropriate value of k which is given by the formula,

$$k = \frac{S(k_i) - S(k_i^2)/S(k_i)}{n - 1} \cdot \tag{6}$$

In this equation k_i represents the number of farms in the i-th crop reporting district and n represents the number of districts. The numerical value of k, which can be regarded as an average k for all districts, is equal to 27,047. The variance of the mean cropland per farm for groups of that size is $8161056/27047 = 302$.

The mean square between the 100 counties for the State as a whole, is 1,194,064. The corresponding value of k, obtained by applying equation (6) to the county data, is 2172.8. The variance of the mean cropland per farm for groups of that size is $1194064/2172.8 = 550$.

The mean square between units for the State as a whole is 7,964. The value of k in this case is not exactly equal to 3 because the number of farms in each stratum enumerated was not an exact multiple of 3. Applying equation (6) to the farms actually present in each unit gives $k = 2.9922$. The variance of the mean cropland per farm for groups of that size is $7964/2.9922 = 2662$.

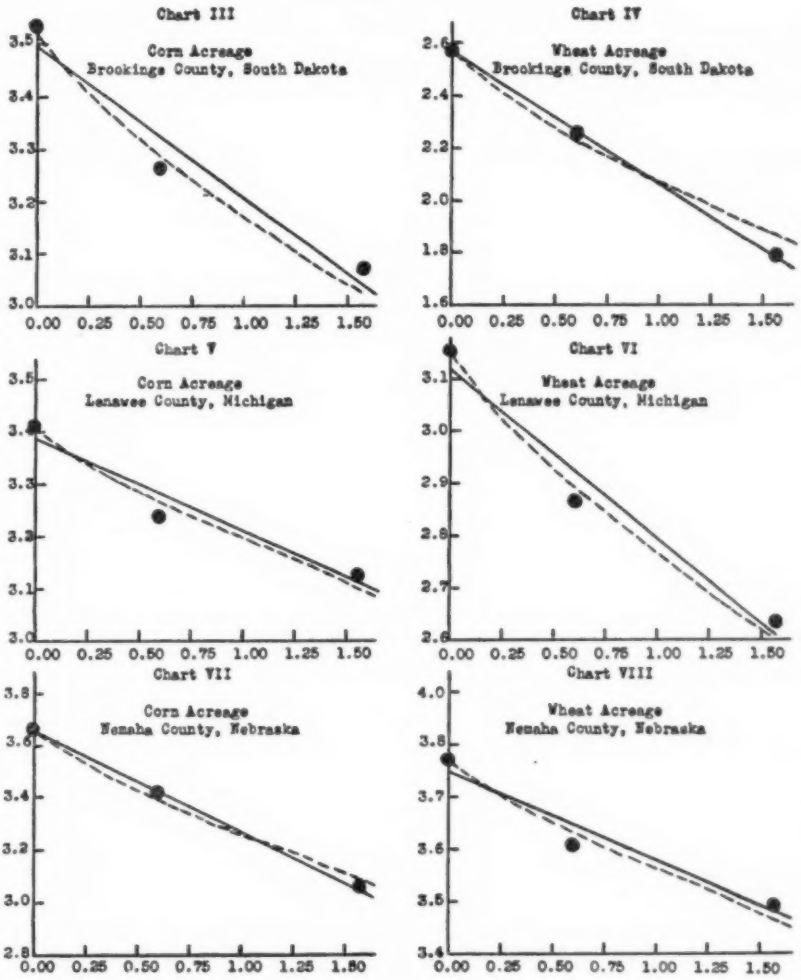
The relation between the variance of the group means and the size of the group is shown in Chart II. The relationship seems to be of the same general type as that encountered in field-plot experiments. The value of a in this case is 0.27137. However, the dispersion of the observed variances of the group means about the straight regression line for small values of k would be troublesome in some practical applications of the theory. If the first two points on the chart were all that were available, the numerical value of a would have been estimated at 0.70073 instead of 0.27137. Although some tolerance should undoubtedly be allowed for sampling fluctuations, it appears that more than sampling error is involved in this discrepancy. This conclusion was drawn after an examination of additional data from other sources.

Several years ago extensive studies were conducted by statisticians of the Bureau of Agricultural Economics in cooperation with the Work Projects Administration of New York City to investigate the efficiencies of survey sections as sampling units for the purpose of estimating crop acreages. Acreages of specified crops on sample sections were measured by planimetering those acreages on aerial photographs. The variance between individual sections, between blocks of 4 sections, and between blocks of 36 sections was computed for an area of 720 sections in each of several counties. Data for corn and wheat

acreages in 3 different counties for this study were supplied to the author by the Statistical Laboratory at Iowa State College. Charts

RELATION BETWEEN VARIANCE OF AVERAGE CROP ACREAGE PER SECTION AND NUMBER OF SECTIONS PER GROUP

Log $V_{\bar{x}}$ plotted against Log k



showing the variability of group averages for groups consisting of 1, 4 and 36 sections within the finite population of 720 sections are shown in Charts III to VIII. In general, the curves described by the plotted variances have the same general shape as the curve described by the

first 3 plotted points in Chart II. The first plotted point is almost always above the straight regression line while the second plotted point is almost always below the regression line. This suggests that the true relationship is not represented by a straight line but by a curve that is concave upwards over the first part of the range. It was pointed out by Fairfield Smith, in his study mentioned previously, that there is a theoretical objection to the use of the straight line represented by equation (5). It was pointed out that the use of this relationship implies that the variance of individual units within groups of a specified size is a function of the size of the finite population sampled as well as the size of the group. Mathematically such a situation is indefensible. The variability of individual units within groups should obviously be independent of the size of the finite population sampled; however, it was also pointed out that, although the mean square within groups was a function of the size of the finite population, the mean square approached a limit for groups of a specified size very rapidly as the size of the finite population increased. For groups of k units the limit approached by the mean square within groups is given by the equation,

$$\text{M.S. within groups} = \frac{k}{k-1}(1 - k^{-a})V. \tag{7}$$

In this equation V does not represent the total mean square in the finite population, but should be regarded as the total mean square in the infinite population of which the finite population is itself a sample. Instead of using the straight regression line represented by equation (5), it would thus appear more logical to assume that the mean square within groups for groups of any specified size should be represented by equation (6) even for finite populations. It is a simple matter to derive an expression representing the variance of the group means from a knowledge of the mean square within groups of size k and the total mean square within the finite population, which could itself be considered a group of size N, where N is the total number of units in the finite population. Such a procedure would insure that the computed mean square within groups of a given size is constant regardless of the size of the finite population sampled. On the other hand, the variance of the group averages within the finite population would then depend upon the size of the finite population. This would be perfectly logical because the variance of group means for groups of a given size when groups are widely separated should be different from the variance observed when they are close together. When the groups are taken from a small finite population, they could be expected to be more

highly correlated with each other than when they are taken from a larger population.

When this relationship was tried, the results were disappointing. The effect of the change was to substitute a curve which was concave downwards for the straight regression line in the charts. The curve tends to be a straight line over the early part of the range and dips downward at the right extremity of the range. This obviously represents no improvement so far as describing the observed data in the charts is concerned. Fairfield Smith's field-crop data apparently followed his empirical law very closely and the refinement just described improved the relationship. However, it appears that the farm data described here follow a slightly different type of law. A study of the variability of farm data within groups of different sizes made by Jessen[3] several years ago indicated that the mean square within groups tends to follow an equation of the form,

$$\text{M.S. within groups} = Ak^b. \tag{8}$$

This equation described his data extremely well and seems to give good results when applied to the data presented here. There is a theoretical objection to using equation (8) for this purpose because it makes no provision for an upper limit to the mean square within groups as the groups become large without limit. Theoretically, the correlation between the units within a group should approach zero as the groups become infinitely large. However, the equation fits the observed data so well within the range of group sizes encountered in practice that there is no practical objection to using it. When equation (8) is used to represent the mean square within groups, the variance of the group averages for groups of size k in a finite population of N is given by the equation,

$$V_{\bar{x}} = \frac{N}{N-k}\left[(N-1)N^{b-1} - (k-1)k^{b-1}\right]A. \tag{9}$$

The curves described by the variances of the group means plotted against group size on logarithmic scales are indicated by the dotted lines in Charts I–VIII. In Chart II the dotted line seems to pass almost exactly through the observed points in the chart. In the other charts the relationship given by equation (9) also fits the observed data better than equation (4), but the differences are not so striking. In some cases the dotted line is farther away from the last plotted point than the straight regression line. This might indicate a poorer

[3] Jessen, Raymond J. "Statistical Investigation of a Sample Survey for Obtaining Farm Facts." *Iowa Agr. Expt. Sta. Res. Bul. 304*, 104 pp. 1942.

fit but such is not the case. The observed points are plotted on a logarithmic scale and a large deviation at the upper end of the range represents only a small deviation in terms of absolute variance. On the whole, equation (9) represents the type of curve described by the observed points much better than equation (4) or the refinement introduced by Fairfield Smith.

In view of these results it is now possible to set up a procedure for the analysis of sampling schemes involving groups of farms as sampling units. For illustrative purposes consider the analysis of variance in Table II, which is a simplification of Table I.

TABLE II

ANALYSIS OF VARIANCE OF CROPLAND FOR 217,976 FARMS IN NORTH CAROLINA BASED ON A RANDOM SAMPLE OF 3-FARM UNITS FROM THE STATE

Source of variability	Degrees of freedom	Mean square
Between 3-farm units	72,848	7,964
Within units	145,127	4,619
Total	217,975	5,737

When the ordinary subsampling theory is applied to this table, the values of V_g and V are first found as follows:

$$V_g = \frac{7964 - 4619}{2.9922} = 1118$$

$$V = 4619.$$

The relative efficiency of a k-farm sampling unit as compared with an individual-farm sampling unit would be estimated from the equation,

$$I = \frac{5737}{1118k + 4619}.$$

For values of k not widely different from 3, such as a series from 1 to 10, this relationship probably provides a fair approximation. But, according to the results presented in this report, it seems more logical to use a different procedure.

The variance of group averages for groups of any size is given by equation (9). The relative efficiency of a sample consisting of grouped units with k units per group, as compared with a sample of individual farms, is obtained by dividing the quantity

$$\frac{N}{N-1}[(n-1)N^{b-1}] \quad \text{by} \quad \frac{kN}{N-k}[(N-1)N^{b-1} - (k-1)k^{b-1}].$$

All of the data needed for the computations can be obtained from the analysis of variance in Table II. The numerical value of b can be obtained from the mean square within units of 3 farms and the total mean square within the entire finite population of 217,976 farms. The process involves fitting equation (8) to the 2 points so specified. The necessary simultaneous equations are as follows:

$$\log A + b \cdot \log (217976) = \log (5737)$$

$$\log A + b \cdot \log (2.9922) = \log (4619).$$

The solution of these equations gives $b = 0.01937$. N is equal to the total number of farms in the finite population, or 217,976. The relative efficiencies of sampling units consisting of from 1 to 10 farms, as computed by the new theory, are compared with figures derived from subsampling theory in Table III.

TABLE III

RELATIVE EFFICIENCES OF SAMPLING UNITS OF GROUPS OF NEIGHBORING FARMS TAKEN AT RANDOM IN NORTH CAROLINA

Farms per units	Relative efficiency	
	Subsampling theory	New theory
	Per cent	Per cent
1	100	100
2	84	83
3	72	72
4	63	65
5	56	57
6	51	52
7	46	48
8	42	44
9	39	41
10	36	39

The differences between the relative efficiencies computed by the two methods are negligible for the range of group sizes under consideration. It is obvious that the groups would have to be made very large before the two series would diverge appreciably, but the new theory is just as easy to apply to actual data as the subsampling theory and it is highly recommended. The subsampling theory appears to be adequate so long as the group sizes under consideration do not depart too widely from the group size used in the analysis of variance from which the estimates of relative efficiency are derived. The newer theory permits valid estimates of relative efficiencies to be made for group sizes which differ considerably from the group size actually used in the original analysis of variance. The numerical value of b in the above

equations as estimated from the analysis of variance in Table II agrees very closely with the value of b obtained from all points shown in Chart II. The value of b corresponding to the dotted curve in Chart II is 0.02240 which agrees closely with the estimate of 0.01937 derived from the data in Table II alone. The use of the curve thus provides approximately the same predicted relative efficiencies regardless of which two observed points are used to establish the parameters of the curve. This is the principal advantage of using the curvilinear relationship in preference to the straight regression line which was first proposed.

SUMMARY AND CONCLUSIONS

The theory of grouped sampling units as applied to farm surveys is discussed from the viewpoint of subsampling and from the viewpoint of an empirical law developed by agronomists. The latter seems to provide the more logical basis for statistical analysis of data involving groups of neighboring farms as sampling units. The use of subsampling theory apparently introduces no serious errors if it is properly used, but the nature of the approximations involved in its application must be borne in mind. The empirical law developed by Fairfield Smith does not appear adequate for predicting the variability of group averages for farm-survey data; the empirical formula used by Jessen for establishing a relationship between group size and variability within groups leads to much more satisfactory results. The newer theory is just as easy to use as subsampling theory and is free from some of the approximations involved in that theory. Subsampling theory seems to lead to results of fair accuracy so long as the range of group sizes considered does not depart too widely from the group size used in the analysis of variance upon which the computations are based. The use of the newer theory permits extrapolation over a wider range.

COST OF LIVING ON FARMS AND PRICES PAID BY FARMERS*

By John D. Black and Althea MacDonald
Harvard University

No section of the public has become as much concerned over the changes in the cost of living of the farm population as certain groups have recently over the changes in the cost of living of families of urban workers. But the subject has been more or less in the minds of farm groups, and particularly of those statisticians responsible for keeping tab on agriculture, ever since index numbers on prices paid by farmers were first issued in 1928. The series now published currently in *The Agricultural Situation* combines commodities used in farm production with those used in farm family living, and in this form of course cannot be used as a cost of living index. Moreover, this series also includes tax and interest payments, as required in an amendment to the Agricultural Adjustment Act passed in 1935. However, the monthly mimeograph release, *Agricultural Prices*, presents separate series monthly for farm production and family living and for these two combined. The February 1944 issue of *Agricultural Prices* presents these same series as annual index numbers back to 1910. The following comparisons show the general relations between these series:

	1910–14	1919	1922	1925–29	1932	1935–39	1943	June 1944
A. Farm production	100	192	139	146	109	127	163	173
B. Family living	100	210	156	161	108	123	170	177
C. A and B combined	100	202	149	155	108	125	167	175
D. Interest	100	180	260	224	188	127	105	105
E. Taxes	100	160	259	272	254	182	179	179
F. C plus D and E	100	198	164	168	124	129	164	170

It thus appears that the A and B series have differed enough at times to make highly necessary their separate use in any measure of changes in cost of living or in farm production costs. The inclusion of interest and tax payments had a very pronounced upward effect in the years from 1925 to 1935, but since 1937, due to the declining rates of interest and volume of mortgage debt, the effect of interest payments has been downward. Tax payments are still running a little higher than commodity prices.

In the final F series, farm production is weighted 37.4, family living 48.6, interest payments 7.2, and tax payments 6.8. In the C series, farm production is weighted 43.5 and family living 56.5. These weights are based on relative expenditures in the 1924–29 period.

* Prepared with assistance from the Committee on Research in the Social Sciences of Harvard University.

The publication of these series in the foregoing several combinations is necessary because of the several different uses needing to be served. The purpose of this article is to consider the suitability of these several series for several important uses, as follows:

1. Changes in farm expenses or costs,
2. Changes in the real prices of farm products,
3. Changes in the real income of the farm population,
4. Parity price and income computations,
5. Effectiveness of price control measures.

FARM EXPENSES OR COSTS

For many purposes it would be highly useful to have an index series showing changes in the prices of goods and services used in farm production. The A series listed above falls short of this need because it fails to include hired labor, veterinary and other services, and insurance, taxes and interest. One can bring in the tax and interest payments as given in the D and E series, but these are not pure price series. That is, interest payments reflect changes in the volume of debt as well as in interest rates. Similarly the tax payments reflect the changes in volume of public services (of road building, educational services and the like) as well as in the prices paid for these.

There have been many proposals of late to include farm labor wages in the prices paid series. In fact, many Congressmen thought that they had so voted when the Anti-Inflation Act was passed in October 1942. At the time that tax and interest payments were voted into the index, to have included farm wages also would have lowered parity prices,[1] and the Congressmen backed away from this proposal the moment they realized this.

The index of farm wage rates rose very fast after January 1941. By the summer of 1942 it had outdistanced the parity index and it was obvious that the spread between the two indexes would widen further. What the farm bloc wanted, therefore, was to combine the two indexes, giving as much weight as possible to the wage index, in order to derive a new yardstick for price control. The farm bloc Congressmen intended "adequate weighting" to mean including proprietor and unpaid as well as hired labor. However, the legal staff of the OPA interpreted this legislation in a highly restricted sense and very few ceiling prices were affected.[2] The House countered by passing the Pace Bill (H.R.

[1] The farm wage index stood as 103 in 1935, compared with 125 for the commodity index of prices paid.

[2] The Anti-Inflation Act was passed under pressure of the dead-line set by the President. Congressman Steagall, in presenting the report of the conference committee on the bill, interpreted the wage rate provision to include all workers on farms. Senator Prentiss Brown reported it to the Senate, however, as including only hired labor.

1408, introduced January 21, 1943), which definitely prescribed the all-labor system of weights. This would have raised parity prices about 15 per cent of the time. The Senate referred this bill back to the committee when strong opposition to it developed in the Corn Belt.

There is need also for an index of total farm expenses as well as of prices or cost-rates—that is, a Price X Quantity index. This will reflect possible substitution of machinery and power for labor, increasing use of fertilizer, and other such changes over the years. In such an index, relatives of total tax and interest payments would fit exactly.

REAL PRICES OF FARM PRODUCTS

About the time of the first world war, agricultural economists began to talk about the purchasing power of the farmer's dollar. The early calculations were made in terms of the BLS wholesale price index. Since 1928, they have more often been made in terms of the BAE index of prices paid by farmers. It is clear that the index series used for this purpose should include exactly the things for which farmers spend the money they receive from the sale of these products, in the proportions in which they distribute their purchases among them. The index series that most nearly fits this need is the over-all series including interest and taxes. Its deficiencies are its failure to include wages of hired labor and the items now omitted from the farm production price index, and certain parallel omissions in the family living index, including education not covered by taxes, medical and dental services, and personal insurance. These latter tend to lag behind commodity prices.

In two recent publications,[3] the senior author of this note undertook to compare the real earnings of labor and of agriculture by using the following wage and price series:

A. Real wages of labor and real farm prices, 1869–1943.
(Bureau of Labor Statistics wholesale price index used in converting both to a real basis) *Parity*, pp. 74 and 78; *R.E.S.*, chart 25.

B. Real hourly earnings of factory workers and real prices of farm products, 1910–43 and for more recent periods.
(Bureau of Labor Statistics cost of living used for factory workers, and Bureau of Agricultural Economics index of prices paid used for agriculture) *R.E.S.*, charts 22, 23.

The first of these charts shows clearly the familiar flattening out of real industrial wages in the years from 1895 to 1915, the sharp rise

[3] John D. Black, *Parity, Parity, Parity*, Harvard University Committee on Research in the Social Sciences, 1942; J. D. Black and Charles A. Gibbons, "The War and American Agriculture," *Review of Economic Statistics*, February 1944.

from 1919 to 1922 to a level somewhat above the secular trend, and the somewhat further net rise in real wages since 1925; and matched against this a scarcely perceptible rise in real prices of farm prices over the whole period until 1941. The second set of charts shows in more detail these divergencies in the two series since 1910–14, in terms of factory workers and all non-agricultural workers.

For some of the purposes which are served by comparisons of returns to labor and to agriculture, farm prices and hourly earning rates are the best measures. One is a return per unit of the labor performed, the other per unit of the product which embodies the labor. It is true that the product also includes some other costs, but only over a decade or two will the contribution of labor to a bushel of wheat or potatoes rise or decline according to whether the production becomes more or less labor-intensive or capital-intensive. To convert these earnings rates and unit prices to a real or purchasing power basis, however, some form of index of prices of things bought should be used. The senior author has used the BLS wholesale series in his 1869–1943 comparisons only because nothing else is available. No criticism is ordinarily raised about using a cost-of-living index with earnings of industrial labor. (The recent controversies have had to do with the accuracy of the particular series now in use.) But using the index of prices paid in this connection raises several doubts. First of all, it includes the goods used in production as well as those used in family living. Income from the sale of farm products, it is true, must pay for the things used in farm production as well as return something net to the farm population as income to spend on their living. But to throw farm expenses and net income into one system of weights assumes more of a constancy of relation between them than prevails. In the early '30s, for example, most of gross income was absorbed by expenses and little was left for family living. In 1943, in contrast, a large part of gross income went into debt payment and various forms of saving.

More important for such a comparison is the circumstance that this prices paid index represents only the price of goods actually bought. Food and fuel furnished by the farm are significant parts of real farm income. In a tentative revised index of prices paid, published in *Material Bearing on Parity Prices*[4] (section 3, table 2), "Items produced" are given a weight of 29 if valued "at prices at which the same

[4] *Material Bearing on Parity Prices* presented by Howard R. Tolley, Chief of the Bureau of Agricultural Economics, U. S. Department of Agriculture, at a hearing on parity prices and income for agriculture before a sub-committee of the Committee on Agriculture and Forestry, United States Senate. July 1941, Washington, D. C. This series was preliminary and for a special purpose and will not be extended.

products are sold from the farm." According to the BAE, data from *The Consumer Purchases Study* now available indicate that a weight of 50 should be given to food in an index including food produced and consumed as well as that bought, instead of the 35.9 in the BAE series now published.[5] If the food produced and consumed were valued at cost in the city, the weight would have been somewhere around 60.

REAL FARM INCOME

However, no comparisons in terms merely of unit prices and unit wages take care of variations in the volume of output and volume of employment. The large agricultural output of 1943 accounted for more than a fifth of the rise in farm income after 1939, and full employment for half the rise in factory payrolls. Such comparisons cannot therefore be final until they are placed on an income or net annual earnings basis. There are four farm income series which may need to be reduced to a real purchasing power basis, namely, cash income from farm marketings, net cash farm income, gross farm income, and net farm income. Earnings of hired farm labor need to be considered as well as those of employers.

For cash income from farm marketings, the combined index of prices paid for goods used in living and production must be used. This the authors did in comparing the real wage incomes of factory workers and real farm income since 1939 and since 1910 in the charts in the article in the *Review of Economic Statistics*.[6] The real farm incomes rise much the faster from 1939, but are still far below real factory earnings measured from 1910. Measured from 1925–29, the farm income series has run somewhat ahead in the last two years. The fit is not too good because of the exclusion of farm wages and the various services named above.

The net cash income series differs from the first in that cash farm expenses are deducted; hence it should be deflated by the index of prices paid for goods used in living. The last two of the income series include the imputed value of home produced and consumed food and fuel. No index series of prices paid now currently published includes these items. The values that would likely be imputed to them would, however, move along with prices received. Including them, moreover, would increase the weightings for food.

Though the net farm series includes the imputed value of home-

[5] If services were included in the index, the weighting for food would be 44; but no data are available for services in 1924–29.

[6] Real annual earnings per worker, labor and agriculture. (BLS index of cost of living and BAE index of prices paid were used to convert these series to a real basis.)

produced food and fuel, there is some question whether it provides adequately for the use of the farm dwelling. This is covered in the current index of prices paid for living only by an item called"building materials for house," given a weight of 7.4.

How well will the index of prices paid for goods used in family living fit the wages and earnings of farm labor as distinguished from the earnings of employer families? If the farm wages converted to real income in this way are wages "without board and lodging," or the imputed value of board and lodging furnished is included in the wage income, it will serve except for the general deficiencies noted. The authors proceeded on these assumptions in a chart in the *Review of Economic Statistics* article previously cited.[7] The chart resulting shows hired farm laborer's real income relatively higher than that of farm operators in 1937–39, but falling behind since. The principal objection to this procedure is that many unmarried hired men living with the farm family do not distribute their cash expenditures according to the same regimens as do operator families. Data are not available for testing the effects of these shortcomings, but they are not likely to be important.

PARITY COMPUTATIONS

It follows from the foregoing that if parity is to be figured in terms of prices, the index series used should include all the items upon which the proceeds from sales of farm products are spent. This will include hired labor surely; also insurance, taxes and interest. None of these, however, should be on a Price X Quantity basis, as at present with taxes and interest. A good case can also be made for including unpaid family labor in the weighting, and even proprietor labor. The parity ratio will then represent a balance between the cost-rates or prices of all the inputs and of all the outputs—that is, all of them except the inputs of management and entrepreneurship, which society does not ordinarily undertake to insure. Perhaps, however, it does need to consider them in the case of small-scale enterprises, especially family enterprises, whether in farm or city.

Obviously a more conclusive treatment of this subject is to work out the parity ratio in terms of net farm incomes and the prices of things bought with such incomes. This procedure has the further advantage that the changing volume of input factors and outputs can be represented in the results.

If the objective, however, is to equalize the real earnings of farm

[7] Real annual incomes of hired farm labor per worker and of farm operator families. (BAE index of prices paid for goods used in family living was employed in the conversion.) *R.E.S.*, chart 38.

people and of industrial workers, or urban workers generally, then no parity ratio in terms of prices paid will suffice—for the simple reason that prices paid by farm groups do not follow closely the wage rates, or hourly earnings, or annual earnings, of wage workers. Thus the hourly earnings of factory workers rose 12 per cent from 1921 to 1929 while prices paid by farmers for commodities rose only 1 per cent. In 1929–32, the lag was in the other direction. From 1939 to 1943, in turn, hourly earnings of factory workers rose 53 per cent while the index of prices paid for commodities rose 38 per cent.

Parity ratios as thus far computed have all been in terms of some base period as representing supposedly an equilibrium condition. There seems to be no immediate prospect of escape from this. Few of those concerned would be prepared to accept the judgment even of a U. S. Supreme Court of Statisticians as to what level of farm returns per worker equals $2,000 a year, for example, earned in our cities. Neither has it been possible thus far to shift generally to some more recent base than 1910–14.

In fact, it has not been possible even to shift to 1935–39 the base period for the weightings in the prices paid index. Not until January 1944 was it deemed safe to shift to 1935–39 the weightings for the index of prices received.[8] The turn of events at that time had brought the index series for prices received figures on the old and new base very closely in line. Shifting the series for prices paid to the 1935–39 base and making other needed changes would reduce it by somewhere around 5 points. (As usually happens, the items whose prices have fallen most have increased most in use.)[9]

Some notion as to the effect of a shift in the index of prices paid to a 1935–39 base may be obtained by examining the following parallels between the series now issued and the preliminary ones on the 1935–39 base released in *Material Bearing on Parity Prices.*

	Goods used in living		Goods used in production		Both	
	Current	Revised	Current	Revised	Current	Revised
1910–14	100	100	100	100	100	100
1925–29	161	156	146	143	155	151
1932	108	102	109	99	108	102
1935	124	120	127	115	125	119
1938	122	119	125	116	123	119
1940	121	118	124	119	122	119

If wages were included in this series, especially if they were given a weighting that included all forms of farm labor, the effect of shifting to the 1935–39 base would be submerged. Congress has not yet lost its

[8] *Agricultural Prices*, January 31, 1944.

[9] In the index series used to compute parity prices, the opposite effect is produced by the lowering of the weights for interest and tax payments in shifting to the 1935–39 base.

interest in the Pace proposal, but it is not likely to take action on it at this session.

EFFECTS OF PRICE CONTROL[10]

As is well known, the OPA was far less successful at the outset in holding in line the prices of farm products and of food than those of most other commodities. Not until the late spring of 1943 did the farm price controls take hold in earnest. The index number of prices received by farmers was 196 in April of this year as compared with 197 a year earlier. By April 1943 the farm price index had risen 90 points from 107 in 1935–39, while the non-agricultural wholesale price index was rising only 34 points.

The general effect of these differences in behavior of prices of the two groups of products is to make gross farm income advance more rapidly than farm expenditures and thus increase net farm income. This result appears clearly enough so long as one deals with the problem in terms of aggregates, but it tends to be concealed in computations of parity based on index numbers. The reason for this is that the index numbers of prices paid include prices of farm products themselves used in production, and also of food purchased for farm family living. This is clear from the weightings used in these index numbers. Those for the production index are as follows:

	Percentages
Feed	27.0
Machinery	11.2
Automobile (share used in farm production) and trucks	12.0
Tractors	3.2
Fertilizer	8.6
Building and fencing materials	15.9
Equipment and supplies	18.6
Seed	3.6

The feed and seed in this list, weighted 30.6 per cent, are themselves farm products, and tend to move in unison with, and roughly in the same amplitude with farm prices themselves. If these are omitted, the index of prices paid for goods used in production would be affected as follows:

	1939	1940	1941	1942	1943
Prices paid for goods used in production	100	102	107	122	134
Feed	100	110	118	147	176
Prices paid for goods used in production excluding feed	100	100	105	117	123

The OPA can indeed say that if feed prices had been kept down to the level of other goods used in farm production, the index of prices paid for agricultural production goods rose only 21 points instead of the 34 appearing in the current index. Similarly, food prices, making

[10] Dr. A. G. Peterson of the BAE supplied the several series with food, feed and seed omitted.

up over a third of the family living index number, move in unison with farm prices and also with farm income, except for the vagaries of the weather.[11] Those interested in showing how effective the OPA has been in keeping down agricultural costs like to point out how little costs of living of farm families have risen if food is excluded. And food prices should be excluded, they infer, because their increase imposes no burden since the farmers have also received the benefit of this rise in higher prices of food products sold. Excluding food from the index of prices paid for goods used in family living has the following effects:

	1939	1940	1941	1942	1943
Cost of living, BLS	100	101	102	117	124
Prices paid for goods used in family living bought by farmers, BAE	100	101	109	128	142
Prices paid, food bought by farmers, BAE	100	100	112	134	152
Prices paid for goods used in family living bought by farmers with food excluded	100	101	110	128	138

Thus the 1943 index number on a 1939 base would be 138 in place of 142 if food prices were excluded. The farm family's cost of living would still appear to have risen 38 per cent as compared with 24 per cent for the city worker's. One reason for this difference is that rents, which figure largely in the cost of living index, have been held down rather effectively, and the same item appears in the prices paid index for the most part only as a small item for building materials. Both clothing and house furnishings have increased more in the BAE than in the BLS indexes. The absence of services in the BAE index is still another reason.

If the two parts of the index, goods used in farm family living, and goods used in farm production, are combined, the results are as follows:

	1939	1940	1941	1942	1943
Prices paid by farmers for all goods bought, BAE	100	101	108	126	138
The same excluding food, feed and seed	100	100	108	122	129

Thus after exclusion of the three items which move more or less in unison with farm prices, the index rises 29 points from 1939 to 1943 instead of 38. This 29 can be compared with the 24 point rise in the BLS cost of living series, but of course the agricultural series includes production costs as well as living costs.

These differences are indeed significant as an analysis of OPA price control. Of the $1.0 million which farm expenditures increased in

[11] The weightings in the index now currently published for commodities used in farm family living are as follows:

	Percentages		Percentages
Food	35.9	Supplies (fuel, soap, auto supplies, etc.)	14.1
Clothing	30.4	Building materials for house	7.4
Furniture and furnishings	5.9	Automobiles (share used for living)	6.3

1942–43, while cash farm receipts were rising $3.8 million, about a third consisted of higher prices for food, feed and seed. The effect of this is to give a 12-point instead of a 7-point increase in prices paid and to effect computations of parity prices in the same proportions.

On the other hand, it must be pointed out that if one's concern is with getting a measure of change in real income, the point raised by the OPA has no meaning. If the rise in farm prices raises farm incomes, it also raises the prices of the foods which must be bought with that income, and should appear on both sides of the ledger. The fact that some of the rise in prices of farm products is reflected promptly in higher prices for goods used in living and production does not call for throwing these items out of the index of prices paid when that index is being used in calculating real farm income. On the contrary, they must be left in unless some method can be devised for removing receipts arising from the final sale of these to farmers from the other side of the ledger. This will be true whether farm prices or farm income per worker is being used as a real or money income.

ON THE SUMMATION OF PROGRESSIONS USEFUL IN TIME SERIES ANALYSIS

By Joseph A. Pierce
Atlanta University

It was pointed out by F. A. Ross[1] that summations of progressions find useful application "in time series analysis where straight lines and more complex curves are fitted as secular trends." Ross presented formulas for the first six powers of the first t natural numbers and of the first t odd natural numbers. He also gave supplementary formulas to be used in fitting a secular trend when the mean of time is taken midway in the time series. These formulas were derived by elementary algebra methods which require a separate and individual derivation for each formula.

The purpose of this paper is to present recursion formulas for sums of progressions which may be used to extend easily the list of formulas given by Ross to include those of higher order.

The series to be considered are

$$\sum_{x=1}^{n} x^r = 1^r + 2^r + \cdots + n^r, \tag{1}$$

$$\sum_{x=1}^{n} (2x-1)^r = 1^r + 3^r + \cdots + (2n-1)^r, \tag{2}$$

$$\sum_{x=1}^{n} (2x-n+1)^r = (1-n)^r + (3-n)^r + \cdots + (n-3)^r + (n-1)^r, \tag{3}$$

$$\sum_{x=1}^{n} \left(\frac{2x-n+1}{2}\right)^r = \left(\frac{1-n}{2}\right)^r + \left(\frac{3-n}{2}\right)^r + \cdots + \left(\frac{n-3}{2}\right)^r + \left(\frac{n-1}{3}\right)^r, \tag{4}$$

for $r=0, 1, 2, \cdots$. We may represent each of these series by

$$S_r = \sum_{x=1}^{n} [a + (x-1)h]^r, \qquad r = 0, 1, 2, \cdots$$

for proper values of a and h.

[1] This Journal, March 1925, pp. 75–79.

We denote the generating function of S_r by

$$G(\theta) = S_0 + S_1\theta + S_2\frac{\theta^2}{2!} + \cdots + S_r\frac{\theta^r}{r!} + \cdots . \tag{5}$$

Since, for $y=a+(x-1)h$,

$$\sum_{y=1}^{n} e^{y\theta} = \sum_{y=1}^{n}\left[1 + y\theta + y^2\frac{\theta^2}{2!} + \cdots + y^r\frac{\theta^r}{r!} + \cdots\right]$$

$$= S_0 + S_1\theta + S_2\frac{\theta^2}{2!} + \cdots + S_r\frac{\theta^r}{r!} + \cdots$$

it follows that

$$G(\theta) = \sum_{x=1}^{n} e^{[a+(x-1)h]\theta}. \tag{6}$$

The right member of (6) may be evaluated by the formula for the sum of a geometric progression and we obtain

$$G(\theta) = e^{a\theta}\left[\frac{e^{nh\theta} - 1}{e^{h\theta} - 1}\right]. \tag{7}$$

By equating the right member of (5) to the right member of (7), we obtain

$$S_0 + S_1\theta + S_2\frac{\theta^2}{2!} + \cdots + S_r\frac{\theta^r}{r!} + \cdots = e^{a\theta}\left[\frac{e^{nh\theta} - 1}{e^{h\theta} - 1}\right]. \tag{8}$$

Expanding the exponential terms of the right member of (8) and then equating, the coefficients of

$$S_r + \frac{rh}{2!}S_{r-1} + \frac{r^{(2)}h^2}{3!}S_{r-2} + \cdots$$

$$= a^r n + rha^{r-1}\frac{n^2}{2!} + r^{(2)}h^2a^{r-2}\frac{n^3}{3!} + \cdots \tag{9}$$

which is the recursion formula for S_r. Formula (9), for proper values of a and h will yield the sums desired but it is considerably less laborious to use individual recursion formulas for each sum.

If we take

$$S_r = \sum_{x=1}^{n} [a + (x-1)h]^r$$

to represent equation (1) then $a=h=1$ and therefore (8) becomes

$$S_0 + S_1\theta + S_2\frac{\theta^2}{2!} + \cdots + S_r\frac{\theta^r}{r!} + \cdots = \frac{e^{n\theta}-1}{1-e^{-\theta}}\cdot \qquad (10)$$

Expanding the exponential terms of the right member of (10) and equating coefficients of $\theta^r/r!$, we obtain

$$\frac{(r+1)^{(1)}}{1!}S_r - \frac{(r+1)^{(2)}}{2!}S_{r-1} + \cdots + (-1)^{i+1}\frac{(r+1)^{(i)}}{i!}S_{r-i+1} + \cdots = n^{r-1}$$

which is the recursion formula for the sum of the powers of the first n natural numbers.

Similarly, recursion formulas for the sums represented by the equations (2), (3) and (4) are respectively

$$\frac{(r+1)^{(1)}}{1!}S_r + \frac{(r+1)^{(3)}}{3!}S_{r-2} + \cdots + \frac{(r+1)^{(2i-1)}}{(2i-1)!}S_{r-2i+2} + \cdots = 2^r n^{r+1},$$

$$\frac{(2r+1)^{(1)}}{1!}S_{2r} + \frac{(2r+1)^{(3)}}{3!}S_{2r-2} + \cdots + \frac{(2r+1)^{(2i-1)}}{(2i-1)!}S_{2(r-i+1)} + \cdots = n^{2r+1}$$

and

$$\frac{(2r+1)^{(1)}}{1!}S_{2r} + \frac{(2r+1)^{(3)}}{2^2\,3!}S_{2r-2} + \cdots + \frac{(2r+1)^{(2i-1)}}{2^{2i-2}(2i-1)!}S_{2(r-i+1)} + \cdots = \frac{n^{2r+1}}{2^{2r}}\cdot$$

COMMITTEE ON NOMINATIONS

President Walker has appointed the Committee on Nominations for 1944.

The Committee consists of

Henry B. Arthur, *Chairman*
Swift and Company
Chicago, Illinois

F. Leslie Hayford
General Motors Corporation
New York City

S. S. Wilks
Princeton, New Jersey

The report of the Committee will be published in the November BULLETIN.

BOOK REVIEWS

GLENN E. MCLAUGHLIN, *Review Editor*

Excess Profits Taxation, by Kenneth James Curran. Washington: American Council on Public Affairs. 1943. vii, 203 pp. $3.00.

This volume is essentially a history of excess profits taxation in the United States. As such, it gives evidence of careful research, is well documented, and apparently accurate.

A particularly useful chapter is that entitled, "Revision by Interpretation, 1918." In this chapter, and elsewhere, the author gives fuller recognition than is customary to the magnitude of the task that fell on the group headed by Dr. T. S. Adams which was called upon to formulate regulations under the Act of 1917; and to the combination of skill and courage with which that work was performed.

After quoting and concurring in contemporary tributes to the value of this work, the author continues cynically: "It was not until 1926 that the inevitable Congressional condemnation occurred." It may well be that the condemnation would have been less severe, and certainly it would have been less justified, if the views of the group as to the termination of the tax had also been followed. They favored the creation of a small commission to dispose of the cases on broad lines. They held that quick disposal of the cases would have a healthy effect on the economy generally, and that, while the war feeling was still alive, settlements could be made that would be acceptable to taxpayers and yet more productive to the revenue than would be the result of long, drawn-out controversies. The millions, refunded to the United States Steel Corporation ten years after the war ended, are but a single illustration of the foresight then displayed but not availed of.

The fact that under the designation "Excess Profits Taxation" two essentially different types of taxes may be and have been levied is brought out in the text. In one case, the levy is sought to be made on the excess brought about by the emergency over profits of normal times; in the other, on an excess over what is thought to be a reasonable rate of return. The author points out that both were combined in the laws of 1917 and 1918. He comments that: "For the sake of simplicity, it would have been better to employ invested capital alone in 1917 rather than to have permitted pre-war profits to play the very minor role that they did." However, the best opinion of the time was that the pre-war profits should be given great weight. If the two principles had not been embodied in the Act of 1917, it might have been difficult to get them recognized in the Act of 1918.

The introduction of the idea of invested capital immediately raises the question whether that capital should be measured in terms of cost or value, and whether it should be the capital invested in the corporation or the capital invested in the enterprise carried on by the corporation that should be re-

garded as significant. These questions have assumed a new importance with the development of the law relating to tax-free reorganizations and the introduction in the field of public utility regulation of a concept of cost to the first person that devoted property to the public service.

The historical narrative contained in the volume is accompanied by some comment on the problems presented, but the discussion is not exhaustive and, particularly, little or no effort is made to compare American and foreign concepts and experience. The value of the volume is, therefore, limited, but within its scope it appears to be authoritative.

GEORGE O. MAY

New York City

National Product, War and Prewar, by Simon Kuznets. New York: National Bureau of Economic Research, Inc. 1944. 54 pp. 50 cents.

In this paper Dr. Kuznets suggests a solution to the problem of measuring gross national product in real terms during the period when the economy shifted from peace to war output. While many economists will question his conclusion, that the national product in real terms increased 47 per cent from 1939 to the first half of 1943, most will agree that he has rendered a distinct service in stressing the valuation (weighting) aspect of real output measures.

Briefly stated, the method involves deflating by means of price indexes those segments of the GNP which measure changes in the dollar volume of nonwar type products, the physical characteristics and terms of production of which have not been greatly altered during the 1939–1943 period. In the case of war output—finished munitions and war construction—however, the author is impressed with the extreme difficulty of deriving a price index for goods, the composition and design of which have been greatly changed during the period. Further, he regards as important the fact that in the prewar period not only was the output of munitions extremely small relative to total output, but also that some of the industries such as aircraft and shipbuilding were immature, producing in small volume generally on a custom basis, however mature in point of time. In both cases Dr. Kuznets argues that the introduction of mass production techniques associated with a large volume of output as well as rapid advances in product design have so lowered unit costs as to grossly inflate a measure of real output weighted with prewar prices of munitions and nonwar goods. While this distortion is relatively small in the prewar years it cannot be dismissed when munitions' output absorbs a large share of the country's economic effort.

As a solution to the problems of deflation and relative valuation of the munitions component of GNP, Dr. Kuznets first derives a measure of the real input of resources which presumably neglects changes in the efficiency of their use. Basically, this series is a combination of the contribution of labor as measured by manhours worked and the contribution of capital and enterprise as measured by minerals used in producing munitions. Each series is

weighted by the value of its contribution in 1939. To answer the question, how adequately does an index of minerals consumption measure the real contribution of capital and enterprise, implies the ability to distinguish in the total return to capital that part arising from productivity changes, since this appears to be included in the assumptions regarding the efficiency of resource use. Similarly, this is true in using manhours as a measure of real labor input. When we add to this the assumption that the contribution of government is equal to prewar corporate income taxes extended for later years by an index derived from manhours and materials, we are in the position of Alice facing Humpty Dumpty.

In translating the measure of resource input into terms comparable with the other segments of GNP in 1939 prices, the attempt is made "to value war output not at actual 1939 prices . . . , but at prices it would have fetched in 1939 had it been produced under conditions comparable to peacetime . . . [with] the efficiency of resource input characteristic of comparable peacetime industries grown to maturity without the urgent haste and waste of wartime."

Taking the position that comparable resources devoted to war relative to nonwar goods are compensated at rates not corresponding to the efficiency of their use, Dr. Kuznets assumes that the efficiency of resources devoted to munitions in the first half of 1943 relative to similar resources used in the metals, petroleum, chemical and construction industries in 1939 varied between 0.8 under assumption *a* preferred by him, and 1.3 under assumption *c*. An increase of two-thirds is allowed in the efficiency of munitions production relative to nonwar output over the period. This combined with assumption *a*, regarding the level of relative efficiency in the munitions and nonwar sectors of GNP, implies that in 1939 the efficiency of resource utilization by the "war industries" in producing munitions was but half that of the same group of industries producing nonwar output.

This is in line with Dr. Kuznets' position that the basis of valuation of war goods is substantially different from that extant in the "competitive" nonwar sector of the economy. Noting that the assumptions concerning relative efficiency are "illustrative" readers may well heed the author's warning to view the results in the same light.

John M. Crawford

Washington, D. C.

Analyses of Minnesota Incomes, 1938–39, by Roy G. Blakey, William Weinfeld, James E. Dugan and Alex L. Hart. Minneapolis: The University of Minnesota Press. 1944. xxvi, 367 pp. $5.00.

This is a collection of three monographs which analyze data from the Minnesota income study, together with an introduction and excellent general summary by Professor Blakey.

In the first study William Weinfeld relates averages and distributions of individual earnings (wages, salaries, and entrepreneurial net income) in

Minnesota to the earner's sex, age, occupation, and weeks of employment, and to the size of community in which he resides. He also relates income of families and single individuals from all sources to various characteristics of these economic units. Cross-classification of principal variables is undertaken in each case. The author's style and disinclination to seek explanations underlying the given data render an intrinsically interesting subject dull reading.

James E. Dugan's analysis of "Housing as Related to Income" is a noteworthy achievement. His goal is discovery of the factors which determine the demand for housing and the fashion in which they operate. The principal investigations relate extent of home ownership and rent paid by renting families to such variables as income, size of community, occupation and family composition. Income effects are successfully isolated from the influence of his other determinants. Information is drawn from Housing Census and Real Property Inventory data, as well as from the Minnesota Income Study sample.

This author sensibly accepts "a fairly regular and consistent relationship between two variables" as sounder basis for reliance upon relationship than the χ^2 or other statistical tests of significance. Hart, in the third section of the book, appears to be of an opposite opinion on this point (p. 252, but see also p. 257).

Sound organization, investigations beyond the given data for explanation of observed relationships, effective use of charts, and novel conclusions enliven Dugan's section of the book.

Alex L. Hart assays data collected in the Minnesota field canvass by three types of test: comparison of income from covered employment reported by 232 earners in the field survey with their earnings as reported by employers to the Minnesota Unemployment Compensation Division; comparison of certain characteristics of the farm sample with the Census of Agriculture; and, by the method of subdivision of the sample, an analysis of randomness from internal evidence. None of the tests is reassuring for schedule-interview surveys. Most disturbing, because least subject to rectification, are the wide errors shown by the first test to exist in the basic data collected in the field canvass. Evidence of a definite downward bias in the field survey (as contrasted with a random distribution of errors of reporting) must be qualified by the consideration that there are 22 chances in 1,000 that the observed bias would arise from chance. A moot point is the extent to which Hart's criticisms of the Minnesota data undermine Weinfeld's and Dugan's analyses. The author offers several suggestions for improving sampling procedures in future surveys, but "questions the wisdom" of attempting to secure income data by the schedule-interview method.

This volume, demonstrating the value of analysis of data by the technicians who prepare them, suggests that such analysis by the technical staffs should more often follow large-scale statistical investigations.

EDWARD F. DENISON

Washington, D.C.

The Displacement of Population in Europe, by Eugene M. Kulischer. Montreal: International Labour Office. 1943. iv, 171 pp. $1.50.

If Dr. Kulischer had reported back to the sponsors of his project that a definitive report on the displacement of population in Europe was not feasible, he would have been correct. The kinds of data essential for such a report are not available, if they exist. It is to Dr. Kulischer's credit that he went through vast masses of fugitive materials to secure the bits and pieces of information from which a systematic history of the war migrations could be outlined. The task of compilation and analysis meant checking and cross-checking, recognizing false propaganda reports, evaluating the reasons why a particular figure was allowed to get into print, and separating out those figures that are usable from those that are not. The results of the survey are necessarily preliminary and provisional, as the author himself recognizes. The report is of great service to all who are concerned with a numerical statement of the displacement of population in Europe. The student who wishes to go further will not need to repeat his systematization of the mass of spotty, contradictory, and generally inadequate data. Sources are cited throughout.

The survey begins with the migration of the German peoples; first, the transfers of German minorities for the purpose of establishing ethnically pure States, then the efforts to settle Germans in the conquered territories, and, finally, the movements of Germans out of Germany as colonists or as officials and employees. Except for Poland, Germany has had a larger rate of population displacement since 1939 than any other country in Europe. Chapter II deals with the movements of non-German populations; the prewar refugees, the refugees fleeing from advancing armies, the movements of people other than Jews who were shifted about in accordance with the changing policies in conquered territory, and the expulsion and deportation of Jews, the territories of destination and methods of confinement, the new ghettos and forced labor camps. The number of Jews expelled and deported from Germany and countries under German occupation or control between 1939 and early 1943 is estimated at 1,080,000.

The third chapter deals with the mobilization of foreign labor by Germany, the extent of emigration of foreign workers into Germany before the war, and the transfers of foreign workers since then—war prisoners, voluntary civilian workers, and civilian workers forcibly brought into the country.

The report concludes that more than 30,000,000 of the inhabitants of the continent of Europe have been "transplanted or torn from their homes since the beginning of the war." Such a figure takes no account of the men in the armed forces or the Todt organization. At best it includes only a fraction of the transfers of workers within the frontiers of individual countries, such as the people who have left cities subjected to bombing, the people who are moved about from place to place in labor battalions, etc.

The data are presented by country and, insofar as possible, in tabular form, supplemented by a number of useful maps.

Conrad Taeuber

Bureau of Agricultural Economics

Unemployment Compensation Experiences of Beneficiaries in Columbus, Ohio: 1939–1940, by Rose L. Papier. Columbus: The Ohio State University, The Bureau of Business Research. 1943. xiii, 82 pp. $1.50.

The introductory statement: "Unemployment has long been recognized as a major hazard in the lives of workers" emphasizes the insurance aspects of unemployment compensation, namely, the pooling of funds to cover the risk of wage loss through unemployment. An interesting array of unemployment compensation objectives follows. These range in scope from speculations emanating from earlier efforts of the State Assembly to draft an unemployment insurance law, to Haber's criteria for evaluating unemployment compensation systems. The former views consider unemployment insurance as an economical means of meeting unemployment costs by stimulating efforts to stabilize employment; whereas, the latter points up the virtues of a completely Federalized system with generous benefits for all.

It was believed that some indication of the effectiveness of the Ohio Unemployment Compensation Law could be obtained through a detailed analysis of information from records essential for benefit payments, although the limitations of such sources for measuring the workers' hazard to wage loss through unemployment were clearly recognized. Some attempt to improvise on the deficiencies of the beneficiaries' records for measuring the hazard of unemployment was attempted through the use of the concepts "exhaustion rate" and "the potential period of non-compensated unemployment." Although the exhaustion rate represents the proportion of all beneficiaries who draw the total number of weeks of benefits to which they are entitled, there is insufficient information to indicate the cyclical impact on this ratio of increasing the maximum number of weeks allowable under the benefit formula. Likewise, the potential period of non-compensated unemployment cannot account for reemployment. The ability of these measures to indicate the effectiveness of an unemployment compensation program is very restricted.

In view of these limitations, and the difficulties encountered in any attempt to get a numerical measure of adequacy, an excellent statistical analysis has been made of the benefit payment experience. Characteristics of beneficiaries' weekly benefit amounts, exhaustion rate, non-compensable period, and period of reemployment of beneficiaries with non-exhausted benefit rights were dealt with in detailed tabulations. Beneficiaries who were disqualified—those required to serve a longer waiting period and receive reduced potential benefits—were segregated from those who were not disqualified. Other classifications of beneficiaries were obtained through occupational and industrial groupings. There are 17 tables in the appendix which thoroughly exploit various possible classifications of beneficiaries by sex, age, weekly benefit amount, total amount of benefits received, months before permanent reemployment for beneficiaries not exhausting rights to benefits and potential months of non-compensable unemployment for beneficiaries exhausting rights to benefits.

Although an excellent analysis of the data available from claimants' records has been made, only a small part of the total picture of the workers' risk to unemployment for a short period has been revealed. If this study were expanded to include a survey of the duration of unemployment and employment of workers in Columbus, Ohio, at the time benefits are paid, a more complete appraisal of the adequacy of the Ohio Unemployment Compensation Law could be made. Duration data similar to that obtained in Croxton's surveys of unemployment and employment in Columbus, Ohio, for the years 1920 through 1924 would be very useful for this purpose.

HARRY J. WINSLOW

New York State Department of Labor

The Movement of Factory Workers: A Study of a New England Industrial Community, 1937–1939 and 1942, by Charles A. Myers and W. Rupert Maclaurin. New York: John Wiley & Sons, Inc. 1943. viii, 111 pp. $1.50.

This study, undertaken by the Industrial Relations Section of the Massachusetts Institute of Technology, is especially valuable as a contribution to method. The project sought to analyze "the interactions of the demand and supply of factory labor in an entire industrial community." It emphasized the movement of factory workers within a local labor market, rather than from one place to another. Two adjacent cities were selected whose total population numbered some 64,000. In these centers about one-half the total employment was in manufacturing industries. Wage levels were not high, and unionism had never been a factor until 1941–42. The period of the study was principally 1937–39; a re-study was made in 1942.

A notable feature of the undertaking was its coverage. Included were some 16,000 workers from firms employing three-fourths of all factory employees in the two cities. For this group, work histories and related data were secured from company records. There was a main sample of 1,539 workers who were laid off or left their jobs voluntarily in the period. For these, more complete data were available; and for a still smaller sample of a few hundred additional information was obtained by personal interview.

It was possible to record information from company records on so large a number as 16,000, because the investigators used the microfilm process. All but a few of the business firms who were approached permitted their records to be photographed. The investigators found this method advantageous on several scores: it caused a minimum of disturbance to business office routine; they were able to collect all the information available very rapidly; and in the material they had a permanent record which could be called upon for detailed analysis as occasion arose.

The findings are of more than usual interest, as mention of a few points will suggest. There was a high labor turnover in this industrial area. More than 70 per cent of workers studied were without steady employment during 1937–39. Less than 15 per cent of these moved among the principal facto-

ries; the large majority "disappeared"—became unemployed or moved into non-factory jobs. About 30 per cent of the moves made were voluntary; 70 per cent were "forced moves," due to layoffs or discharges. Even in the wartime market of 1942 forced moves still predominated. A strong tendency was noted for workers to move between industries and firms located in the same neighborhood. The movement in the direction of higher-wage firms was not very great. Noteworthy barriers to free movement were discovered on both the demand and supply sides of the labor market; of special interest in this particular community was a "gentleman's agreement" among employers not to hire away from one another, or attempt to outbid, although this had given way to some extent in 1942 under pressure of war contracts. Other interesting contrasts between 1937–39 and 1942 were noted. A main limitation of the study, say the authors, was lack of data on the experience of certain groups of workers, such as those who moved out of factory work into non-factory jobs or unemployment.

A further limitation, one that is unavoidable in such studies, lies in the special characteristics of the particular industrial community investigated. If the same methods, so successfully used here, could be applied to other types of local labor markets, even those much larger and more complex, it would be a valuable contribution indeed. The study is to be highly commended and should be read without fail.

KATHARINE DU PRE LUMPKIN

Institute of Labor Studies
Northampton, Massachusetts

Earnings and Social Security in the United States, by W. S. Woytinsky. Washington: Social Science Research Council, Committee on Social Security. 1943. xiii, 260 pp. $2.50.

This book represents a comprehensive analysis of wages and earnings as related to all the more important factors affecting their level and distribution. Relationships and comparisons are all presented in brief summary tabulations and charts interspersed throughout a smoothly flowing text. The result is a readable volume for those primarily interested in description and a well-organized reference for those having occasion to make use of wage or earnings data for analytical or statistical estimating purposes. The materials presented will be found particularly useful for those interested in making analyses of the probable impact of changes in social security programs, of minimum wage provisions, and of income and other tax programs based on wages or earnings.

Data collected through the operation of the old-age and survivors insurance program constitute the primary source of the statistical materials analyzed, although other sources, such as the wage and hour studies of the Bureau of Labor Statistics and the income estimates of the Department of

Commerce are used where pertinent—particularly for comparison with old-age and survivors insurance data.

Much of the verbal analysis and conclusions drawn is directed toward problems related to the administration, policies, and provisions of the social security program. Particular attention has been given by the author to pointing up the materials for use in estimating long-time trends in coverage, costs, and trends.

The following is a brief outline of contents:

1. The introduction consists of a brief description of the statistical methods used in the analysis of wage and earnings distribution and their inequalities.

2. The number and earnings of wage and salary workers covered by the social security program are compared with the total number of wage and salary workers and their earnings. Factors analyzed include variations as between income levels, industry, and state.

3. Levels, inequalities, and variations of wages for families and individuals are related to such factors as industry, occupation, age, sex, color, state, continuity of employment, and whether covered or not by the social security program.

4. The long-range trend in per capita income and wages is analyzed and related to long-range estimates of benefits and contributions under the old-age and survivors insurance program. Long-range trends are also analyzed in terms of relationship between wages, prices, and national income.

5. The final sections of the book analyze old-age and survivors benefits by type of payment (to retired workers, to their wives and widows, and to their children under 18) and by state; and relate the economic status of families and individuals at different stages in their life cycle to levels of earnings and the need for social security.

EMMETT H. WELCH

War Manpower Commission

The Mining Industries, 1899–1939: A Study of Output, Employment and Productivity, by Harold Barger and Sam H. Schurr. New York: National Bureau of Economic Research, Inc. 1944, xxii, 452 pp. $3.00.

This study constitutes an addition to the three volumes previously issued by the National Bureau of Economic Research on output, employment and productivity in American manufacturing and agriculture from 1899 to a recent prewar year. New indexes are made available which are coordinate with those for manufacturing and agriculture. Although the presentation of these indexes is the chief purpose of the volume, somewhat extensive collateral information is given on resources, discovery rates, production techniques and consumption of minerals.

Weights assigned in the various indexes of output are analogous to those in the Federal Reserve index, and results are similar. Rather close agreement

with the earlier Edmund E. Day index also is recorded for the period of overlap, 1899–1923. On the other hand, the departure from the National Research Project index is wide, the NBER index showing a much stronger upward trend. This difference is due to the use of employment weights for output in the NRP index, which assigns a heavy weight to the weak series, such as coal mining, whereas the value added basis of the NBER index gives greater importance to the strong series.

It will be a surprise to economists who have assumed that minerals output is a declining factor in the economy that the minerals index in the 40-year period ending with 1939 rose almost as rapidly as the manufacturing index and far outdistanced the agricultural index. Production of petroleum and natural gas and certain non-metallic metals, such as sulfur, potash, bromine and borates, accounts principally for the strength of the minerals index. Metals output grew only a little more than one-third as much as total fuels output in the 40-year period. Fuels are less important as a direct part of the product in manufacturing than as a source of energy for heat and power. Imports and exports of crude and semi-manufactured minerals are a small share of domestic output. It may still be true, therefore, that minerals going into manufacturing as a part of the product are a declining ingredient in the end-product valuation.

Moreover, the border line between mining and manufacturing is extremely important. It happens that the definition of manufacturing includes all processes except a very few such as cleaning and beneficiation of minerals. A good case can be made for including smelting and refining in minerals production. The basic materials for multiple uses in manufacturing are not the crude minerals so much as the refined minerals. Competition between bauxite or other crude sources of aluminum and iron ore, for example, is much less direct than between refined aluminum and pig iron or raw steel. The same is true of competition among plastics, metals and the whole gamut of other minerals. If we chose to count smelting and refining with mining instead of with manufacturing, an element of growth retardation would be taken away from manufacturing and added to mining. Trends in the metal industries would be especially affected.

Employment data utilized in the volume are generally not the numbers of persons employed. What is usually meant is working time in terms of mandays or manhours. This usage is so prevalent throughout the study and data on numbers employed are so sparse that the title would have been more accurate had it referred to working time instead of employment. Much investigation remains to be done on the number of individuals engaged in mining industries. Basic information on this important subject is not now satisfactory. For even such a leading industry as petroleum, basic series are either lacking or are far from reliable. Mining industries have a larger share of part-time and intermittent labor than manufacturing. Nevertheless, in conformity with the impression conveyed by the title of this study, averages of employment comparable with those of the Census of Manufactures could be shown more freely.

One should note that, in the study, productivity merely refers to output per unit of working time and does not necessarily indicate potentialities. Certain mining practices, for example, the drilling of shot holes by hand and the loading of fixed quotas of cars in the anthracite industry, are admittedly inefficient. In mining as in most other industries, a gap usually exists between the actual and the best practice. A shift from hand to mechanical operation would tend to increase the spread. Productivity data based on actual output per unit of labor time do not allow for such technological lags.

In agreement with the policy of NBER, the volume undertakes to present facts with a cautious theorizing as to implications. Anyone who has delved into the comparatively abundant but loosely coordinated and inconsistent mining data will recognize the careful workmanship that has gone into assembly and presentation of the data. As a factual study, the volume unquestionably is without a rival in the mining segment of our economy.

Wilbert G. Fritz

Program Bureau
War Production Board

Railway Traffic Expansion and Use of Resources in World War II, by Thor Hultgren. New York: National Bureau of Economic Research. 1944. 31 pp. $.35.

Railway Wage-Rates, Employment and Pay, by John L. McDougall. Toronto: Longmans Green & Company. 1944. 34 pp. $.50.

These two pamphlets treat various phases of railway experience with special reference to the war period. Mr. Hultgren's paper is primarily a straightforward account of the growth of wartime railroad traffic and the changes in the various operating and revenue measures which accompanied it. It indicates the means by which large increases in business were handled with much smaller increases in the plant, manpower, and fuel devoted to it. The increased utilization obtained from equipment is clearly demonstrated and some of the methods used to obtain such enhanced productivity are touched upon. The paper aims, however, more at exposition of the results than their explanation. No attempt is made to go into the technical background of operating methods, equipment maintenance, etc, which have contributed so largely to the results recorded. The treatment of the present war experience is enhanced by comparison with World War I. Charts highlight the behavior of certain indexes of railroad performance, showing, for example, the limits beyond which number of cars per train do not increase, though trainload continues to grow at a much reduced rate as average carload increases. The paper should serve as a most convenient and useful summary of railroad traffic and operating experience during the period of sharp growth of war traffic.

Mr. McDougall treats a subject of profound interest and great current significance. Although in Chapter 5 he points up his results in terms of the

immediate problems of wartime wage and price control, the study is based on an examination of railway wage, employment, traffic, and earnings data for the United States and Canada over the full period for which comparable statistics are available. Correlation technique is employed throughout and very high accuracy of prediction is obtained. The present pamphlet is a "popular summary" of a larger work begun in 1941 and scheduled for later publication. It presents the high points of the analysis and the conclusions which it seems to demonstrate. McDougall draws attention to the hypothesis that wage payments in the railroad industry are limited by operating revenues. From his correlation analysis he presents formulae showing the extent to which (1) a rise in the wage rate will reduce employment, revenues remaining constant; (2) a rise in revenues with wage rates constant will increase employment; (3) a rise in hourly wage rates or in operating revenues will increase average yearly earnings. He points up the conflict between the short-run interest of the older employees, protected by seniority, and the long-run interest of labor as a whole in the maintenance of employment as well as the differential effects of a high wage policy on the part of the best organized men upon others less strongly entrenched. This concise presentation is perhaps the first statistically to treat a problem that has long aroused sharp controversy. Findings are sharply stated; the high accuracy of prediction stressed; and the close conformity in behavior of United States, Canadian, and British (where available) data is emphasized. The treatment might well be rounded out by a consideration of the means employed by carriers to accomplish displacement of labor with rising wage rates—more rapid introduction of mechanical equipment, changes in service, etc.—and their effects upon the shipping and travelling public and in the end upon the volume of traffic available.

ERNEST W. WILLIAMS, JR.

War Production Board

Tea under International Regulation, by V. D. Wickizer. Stanford University: Food Research Institute. 1944. vi, 198 pp. $2.50.

Another "must" book for students of international food control has been written by Mr. Wickizer, with the support of the Food Research Institute and the Rockefeller Foundation. He has composed a symphony with many such arresting themes as: tea, a typical product of the Orient and of cheap labor; tea exports chiefly from black tea estates in India, Ceylon, and the Dutch East Indies; relatively stable rates of production and relatively stable demand by importing countries; domination of production, manufacture, transportation, and distribution by the British almost unique (United Kingdom absorbing half the world's tea exports and 70 per cent of British domestic distribution handled by four blender-distributors); two-thirds of importing market within the British Empire (United Kingdom annually consuming 9 pounds, United States 3/4 pound per capita).

Falling prices and mounting stocks induced producers' associations of India, Ceylon and the Dutch Indies to limit 1930 production—producers of cheaper teas reducing output more than growers of finer teas because the cheaper or "filler" teas enjoy a livelier demand in a rising market. The 1933 agreement prohibited new planting unless "the existence of a tea estate would otherwise be imperiled." The export of tea seed and slips was prohibited. By 1943 tea prices and estate shares showed recovery.

Under the first five years of tea regulation the greatest disappointment was the failure of tea consumption to expand as anticipated.

Control for another five years began April 1, 1938, and stipulated that, if production in any country greatly exceeded export quotas plus local consumption, that country should immediately restrict such excess production.

Mr. Wickizer attributes the comparative success of tea control to the restraint of the controllers in not unduly protecting the marginal producers and in aiming at stabilization rather than a valorization or elevation of prices. That restraint moderated the encouragement afforded competitive and unregulated producers to increase production, while giving relief from excessive fluctuations.

International food control under the plans of the United Nations is of rising importance and Great Britain promises to play, after the war, a leading role both in importing markets and in very important producing areas. British interests are likely to be protected or directed by the British government. Hence British tendencies and capacities are quite worthy of any reader's serious attention. They are well scrutinized in the little volume under review.

Carol H. Foster

Washington, D. C.

Food Rationing and Supply, 1943–44. League of Nations Publication. New York: Columbia University Press; Economic, Financial and Transit Department of the League of Nations. II. A. 3. 101 pp. $1.00.

This report follows another in the same series, entitled *Wartime Rationing and Consumption* which gives a general description of rationing systems and information on goods other than food.

In three chapters we are given a comprehensive, round-the-world view of food rationing and food supply as it was toward the end of 1943. Most emphasis is naturally placed on the European situation. Information is least for Russia and Japan.

Chapter I is devoted to "Food Rationing and Consumption" and gives an excellent description of "legal rations." Chapter II, "Nutrition and Health" discusses measures of health and vitality. Chapter III is entitled "Production and Supply" and briefly surveys the world food supply situation and its changes during the war.

The limitations, statistical and otherwise, on the use of "legal ration" data

as an index of actual consumption are very properly indicated at the outset. In the United Kingdom and probably in Germany the full rations are available, but in the German occupied areas there is great diversity in the extent to which the rations are supplied. Another variable is the "black market" which in various degrees flourishes everywhere.

On the basis of the legal rations at the end of 1943, the Nations of Europe fell into four regional groupings. At the top were Germany, Denmark, Bulgaria, Rumania, and Hungary with rations supplying a theoretical caloric intake sufficiently high to meet accepted average requirements of 3,000 calories a day per adult male. This is up to prewar levels. The vitamin and mineral content of the rations was also good.

In the second group were Belgium, Netherlands, the Protectorate of Bohemia and Moravia, Finland, and Norway with rations representing between 2,500 and 2,800 calories per day—or below prewar. With some exceptions, the quality of the rations was as good as in Germany.

In the third group were the Baltic States, Slovakia, France, and Italy with from 1,500 to 2,400 calories per day, definitely too low for health and sustained work.

The fourth group included Poland, Greece, Yugoslavia, and occupied Russia in which rations in 1942 were at famine levels and although improved in 1943 were still extremely deficient.

In the United Kingdom and the neutral nations (except Spain) the food rations were generally more favorable than in Germany. The British appear actually to have raised their nutritional level despite significant shifts in food habits.

In the Americas and the British Dominions food rationing has been used mainly as a means of making price controls more effective.

In Chapter II attention is turned to vital and health statistics. Most of the available direct measures are negative. Changes in birth and death rates and infant mortality are rather small but some regionalization is apparent. The United Kingdom, Sweden, Switzerland, and Denmark have actually reduced the civilian death rates during the war. Germany has apparently fared less well than Netherlands and the Protectorate. But in Italy, France, and Belgium the situation is graver, and in Poland, Greece, Yugoslavia, and occupied Russia it has been very black indeed.

Some of the scattered and incomplete statistics as to the prevalence of disease give evidence of serious malnutrition. A rapid increase in tuberculosis in French and Belgian cities and a greater incidence of diphtheria and scarlatina in several areas are noted. Some of the other serious diseases have increased but not to epidemic proportions.

The third and last chapter on "Production and Supply" is a somewhat sketchy survey of the changes in world production through the war years. Some important aspects are largely passed over as, for example, the effect on the Allied food supply of the loss of the East Indies to the Japanese. The discussion of changes in production of food in the United States correctly points out the wartime emphasis on livestock but undervalues the signifi-

cance of the crop changes that have taken place. It is stated that acreage of cereals in the United States decreased from 1942 to 1943, when an increase actually took place. This slip seems to have occurred because the British apparently do not count corn as a cereal.

The first three years of the war saw an expansion in food production in allied territory and a contraction on the continent outside Russia. In 1943, however, the continental situation improved with higher crop production.

The over-all impression gained from the report is that both sides have been more successful in handling the food situation in this war than in World War I. There is no immediate prospect that food shortages will contribute much to the defeat of Germany. The real victims have been those in areas under German control whom the Germans found it difficult or inconvenient to supply with food.

Ronald L. Mighell

Bureau of Agricultural Economics

Costs of Dental Care for Adults under Specific Clinical Conditions, by Dorothy F. Beck. American College of Dentists. Lancaster: Lancaster Press, Inc. 1943. 306 pp.

This monograph represents perhaps the most thorough and enlightened exploration yet available of the general issues involved in the problem of assaying and meeting the dental service needs of adults.

Section One deals with historical and descriptive material concerning (a) recent trends in public dental care including various legislative proposals bearing on the problem, (b) previous studies on time and costs of initial and maintenance care, and (c) methods used in estimating costs and the difficulties involved in the development of such methods.

Section Two provides information on (a) the type of patients included in the sample, and (b) basic averages for total initial and annual maintenance time and costs.

Section Three is devoted to summary and general discussion in which is included a rather full statement of the implications of the findings for private practice as well as for the problem of extending dental care to the entire population.

At first glance, the reader of this monograph may be led to conclude that actuarial findings on time and costs involving a total of only 485 adults in New York City hardly justify a descriptive monograph covering more than 300 pages of text and tables. A careful reading of the publication, however, quickly dispells such a conclusion; for the sample of 485 adults is used to fullest advantage as an illustrative example in order to facilitate discussion and consideration in the most thorough manner, of all the basic concepts and difficulties involved in the analysis and interpretation of future findings which will deal with the need for dental service among adults. The main value of the monograph lies not in the statistical tables covering a small

sample of adults, but rather in the description and elaboration of methodologies which will be of considerable usefulness for other workers of the future, who will deal with larger and more representative samples of the whole population.

HENRY KLEIN

U. S. Public Health Service

Criminal Careers in Retrospect, by Sheldon and Eleanor Glueck. New York: The Commonwealth Fund. 1943. xiv, 380 pp. $3.50.

The study pertains to the careers subsequent to discharge from the Massachusetts Reformatory, of 510 persons who completed their sentences in 1921 and 1922. Two previous reports have been made dealing with the findings after the elapsing of five and ten years, respectively. The present book is the third in the series and deals with the 15-year span since discharge. Out of the original number, 439 were alive at this anniversary and about 94 per cent of these have been traced.

The book is divided into three parts, the first of which brings the history of the individuals up to the 15-year point; the second deals with the comparison of successes and failures on various axes of treatment background and personal characteristics; the third deals with prediction possibilities.

The presentation is partly in terms of case histories and partly in statistical terms. The numerical material is extensive but is largely incorporated in the text rather than put in tabular form. This makes it hard to judge the comparisons critically especially since the classes compared are often overlapping and do not emerge clearly in the text. The use of classifications which are not mutually exclusive leads the authors themselves astray in their interpretations, for they call attention to the consistency of the direction of differences for various classifications, when the classes are not independent. For example, p. 127, the reformed and unreformed are compared as to the percentage falling in such classes as first delinquent under age 14, first left home under age 14, parents economically dependent, and so on. Consistency in such comparisons doesn't mean much until we know to what extent the comparisons are independent.

Nearly 100 pages of the book are concerned with prediction of behavior by means of prognosis tables in which the combined "failure score" of the individual on certain traits is the argument. The authors state that the tables are not recommended for use at the present time since they have not been validated. They point out that they could have been validated by dividing the cases at random into two groups, one of which could be used to work out prediction tables and the other to test the predictions. They did not do this, however, nor is it clear what their evidence is for stating (p. 219) that "the chances of the predictions being high would be good, especially in the larger series of a thousand cases used in *Juvenile Delinquents Grown Up*." Actually if their prediction tables do not hold up when they come to be

tested in another series, a large series would reveal their defects more definitely than a small one.

Of the three prediction tables, 18, 19, and 20, the last two contain a major difficulty due to the fact that they are not based on complete subclassifications. Table 18 shows for each group of "failure scores" the percentage who remain serious offenders, who become minor offenders, who reform entirely, and who have temporary lapses after reform. The table can be entered with a given score and the probability of a person falling into each of these four categories ascertained. Tables 19 and 20 attempt an age subclassification, but instead of making this complete so that a person of a given age and failure score could get a prognosis, they show for each failure score what percentage of those who became minor offenders were under age 27 and what percentage over 27 (Table 19) and what percentage of those who reformed entirely were under 27 and over 27 (Table 20). Thus in the latter table those who reform entirely are now 100 per cent, yet the authors refer to their age distribution as giving "the probable age at reformation" and also as giving the chances of reforming while under age 27 or at 27 or older. Actually it gives neither. That the authors are misled by these tables is shown repeatedly in their illustrative examples. Thus, p. 229, they use Table 18 to show that "Robert's chances of reformation were . . . three and one-half in ten" and in the same paragraph they use Table 20 to show that "Robert, with a failure score of 167.4 had only two chances in ten of reforming when under 27 years of age, but almost eight changes out of ten when 27 years or older."

The prediction tables are dubious, therefore, not only because they have not been validated but because they do not give prognosis figures specific for variables that are of importance in the problem.

Margaret Merrell

School of Hygiene and Public Health
The Johns Hopkins University

How Nazi Germany Has Controlled Business, by L. Hamburger. Washington: The Brookings Institution. 1943. 101 pp. $1.00.

In recent years there has been a series of books which have attempted to determine the nature of the Nazi economy. So far as the basic interpretation of Nazism is concerned, these books fall into two general categories. One school of thought says that Nazism involves political totalitarism and extensive government regulation but still may be identified with capitalism. The other school of thought, whose most notable spokesmen are Stolper, Burnham and Lederer, denies the capitalist character of the Nazi economy. Although L. Hamburger in *How Nazi Germany Has Controlled Business* contributes no new information, he does provide a short well-written summary for the case that Nazi regulation of business has done a job equivalent to nationalization or outright government ownership. This amounts to saying that the Nazi economy is not capitalist and is an enticing view since it makes

the differences between National Socialism and democracy appear to be not only political and ideological but also economic. It sees the two as fundamentally different economic systems, as private capitalism and brown bolshevism.

The spokesmen for the other school of thought agree with Hamburger concerning the extensiveness of the controls but disagree with him concerning their significance. They maintain first that capitalism must be defined to include monopolies and government intervention and should not be described in terms of the model established by the classical economists. Secondly, they insist that the profit motive is still a generating force in the Nazi economy. They point out that in a monopolistic system it is difficult to maintain profits without the totalitarian political power which is the distinctive feature of National Socialism. If totalitarian political power had not abolished freedom of contract, the cartel system would have broken down. If the labor market, raw materials, prices, credit and exchange control offices were in the hands of forces hostile to monopolies, the system of monopoly profits would be threatened.

Nazism is thus the dictatorship of the National Socialist party, the Bureaucracy, the Army, and big business for complete organization of the nation for imperialist war. Preparation for totalitarian war requires huge expansion of the production-goods industry and makes it necessary to sacrifice conflicting economic interests. This, in turn, requires the incorporation of the total economy into the monopolistic structure. It means that the automatism of free capitalism, precarious even under a democratic monopolistic capitalism, no longer exists. But capitalism of a monopoly form still remains. National Socialism utilized the daring, the knowledge, the aggressiveness of the industrial leadership, while the industrial leadership utilized the anti-democracy, anti-liberalism and anti-unionism of the National Socialist party which had developed the techniques by which masses can be controlled and dominated.

MAXINE SWEEZY

Washington, D. C.

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* Annual reports and publications presenting statistics collected at regular intervals have been omitted from this list. Some items of minor interest to statisticians have also been omitted. The contents of periodical publications are not listed, but the attention of the reader is directed to the lists of articles in current publications which are to be found in the *Revue de l'Institut International de Statistique, Journal of the Royal Statistical Society, American Economic Review, Population Index, Transactions of the Actuarial Society of America, The Record of the American Institute of Actuaries,* and *Sankhyā, The Indian Journal of Statistics.*—Editor.

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